ESSAYS ON MONETARY POLICY WITH STERILISED INTERVENTION IN EMERGING MARKET ECONOMIES

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ABSTRACT

The purpose of this thesis is to provide a new simple theoretical framework for understanding the sterilisation of foreign exchange intervention within a monetary policy framework where a short-term interest rate is the main policy instrument. Another aim is to carry out new empirical analysis that compares and contrasts the effects of intervention on base money growth with its effects on broad money growth, and to investigate if these effects are associated with common country characteristics in terms of the nature of intervention, balance of payments flows and monetary policy frameworks.

Using a portfolio balance model and simple balance sheet constraints, it is shown that base money sterilisation does not imply broad money sterilisation. Incomplete broad money sterilisation, when intervention is a positive money supply shock, leads to looser monetary and financial conditions, even as base money growth is completely sterilised in an interest rate-targeting framework. With a progressively lower degree of broad money sterilisation, the policy interest rate in an optimal monetary policy reaction function needs to respond more strongly to the exogenous factors affecting the output gap and inflation.

The empirical analyses of the contemporaneous and long-run effects of real intervention on real base money growth and real broad money growth are carried out using multivariate autoregressive distributed lag (ARDL) regressions for individual countries. These regressions include controls for demand factors. The focus on a reasonably large sample of 30 countries, with individual country heterogeneity taken into account, and the emphasis on broad money sterilisation represent a clear departure from existing empirical literature.

The empirical results reveal that on average, the real intervention effect on real broad money growth is higher than and disconnected from the effect on real base money growth. The baseline group average short-run and long-run coefficients are 0.122 and 0.496 respectively for real broad money growth and 0.075 and 0.111 respectively for real base money growth (excluding outliers, Egypt and Taiwan, in both instances). With regard to the relevance of country characteristics, a general lack of statistical significance is observed across mean and median equality tests and bivariate regressions. This is not unexpected with regard to real intervention effects on real base money growth, but indicates that the real intervention effects are very much country-specific in the case of real broad money growth. In particular, there is no evidence of a difference in real intervention effects on real broad money growth between inflation-targeting and non-inflation-targeting countries. The short-run and long-run real intervention effects on real base money growth are found to be robustly associated with differences in capital account openness although these differences are not of a monotonic nature. Meanwhile, the short-run real intervention effects on real broad money growth have a positive, monotonic association with current account surpluses and concurrently a negative monotonic association with capital account surpluses. On the other hand, the long-run real intervention effects on real broad money growth do not appear to be robustly linked to any particular country characteristic in a statistically significant manner.

A key implication of the thesis is that broad money sterilisation matters, not base money sterilisation, in understanding how balance of payments flows and intervention permeate the economy. Complete broad money sterilisation, however rarely occurs. Furthermore, regardless of the degree, broad money sterilisation, seen as a blunt instrument, may have unpredictable and undesirable effects, owing to uncertainties over money demand and money supply shocks, and mismatches in asset demand and supply. The model presented provides a framework for understanding the continued reliance on measures such as prudential policies and restrictions on capital flows in dealing with financial imbalances; this despite seemingly successful sterilisation by way of the containment of base money growth.

Keywords: monetary policy, exchange rate, foreign exchange intervention, money, sterilisation, emerging markets, inflation-targeting

JEL Codes: E51, E52, F31, F33

Disclaimer: The views expressed in this thesis, unless otherwise indicated, are those of the author, and should not in any way, be construed as reflecting the position of Bank Negara Malaysia.

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TABLE OF CONTENTS

List of Tables

List of Diagrams

List of Graphs

CHAPTER 1

INTRODUCTION

"The one thing a central bank can do
is to flood the market with liquidity"

Alan Greenspan,
Chairman of the Federal Reserve (1987-2006)
in the BBC's The Love of Money.

1.1 BACKGROUND

The main motivation for this thesis is to provide a simple theoretical framework for understanding the sterilisation of foreign exchange intervention within a monetary policy framework where a short-term interest rate is the main policy instrument; and to carry out new empirical analysis on the extent of sterilisation in emerging market economies according to this conceptual structure. It is our assessment that such cohesiveness appears to be lacking in recent empirical literature.

The concept of the impossible trinity states that a country cannot simultaneously attempt to achieve the three goals of monetary policy independence, exchange rate stability and free international capital mobility. The ability to intervene in the foreign exchange markets enables the central bank to manage the exchange rate. At the same time, the capacity to neutralise the impact of liquidity generated from intervention – that is to sterilise, allows the central bank to focus monetary policy on domestic considerations. Policy difficulties arise from the ease of substitutability between domestic and foreign assets; the availability, balance sheet costs and macroeconomic consequences of sterilisation methods; and when resisting exchange rate depreciation, reserves depletion. The experiences of emerging market economies have come under renewed scrutiny over the last 10 to 15 years as vast amounts of foreign exchange reserves have been accumulated amidst large global capital flows and widening current account imbalances.

Many theoretical and empirical studies pertaining to sterilisation in developed countries were carried out in the 1970s and 1980s. These include Argy and Kouri (1974), Herring and Marston (1977) and Obstfeld (1983). The analyses are carried out based on the portfolio balance framework which synthesises the monetary approach to the balance of payments with equilibrium conditions in several asset markets, namely the bond and money markets. The change in the central bank's net domestic assets (ΔNDA) is assumed to be the monetary policy instrument, and the sterilisation coefficient is typically embedded in a monetary policy reaction function of the form:

$$\Delta \mathrm{NDA}_t = \alpha + \beta \Delta \mathrm{NFA}_t + \gamma \mathbb{Z}_t + u_t \tag{1.1}$$

$\mathrm{NDA}_t =$ the central bank's net domestic assets.
$\mathrm{NFA}_t =$ the central bank's net foreign assets, which increases as the central bank buys foreign currency and sells domestic currency as part of its foreign exchange intervention operations.
$\mathbb{Z}_t =$ a set of explanatory variables which represent the objectives of the central bank.
$\gamma =$ a set of coefficients on $\mathbb{Z}_t$.

In (1.1), β measures the degree of sterilisation, with a value of minus one indicating full sterilisation. We refer to β as the measure of base money or narrow sterilisation. $\mathbb{Z}$ represents a set of explanatory variables that capture the domestic objectives of monetary policy. The sterilisation equation may be estimated as part of a system of simultaneous equations, where the second equation is the offset equation, which estimates the extent to which a monetary policy action is countered by a balance of payments effect. The offset equation thus relates to capital mobility[1]. The $\mathbb{Z}$ set tends to be rather arbitrarily determined.

Recent empirical studies have continued to employ this general estimating equation (equation (1.1)), with variations in the choice of control variables. Brissimis *et al*. (2002) provide a unifying theoretical framework in which both the monetary policy reaction function and foreign exchange intervention can be jointly determined. With the resulting just identified simultaneous equations, they estimate sterilisation and offset coefficients for Germany over the period 1979-1992. Ouyang *et al*. (2008, 2010) and Ouyang and Rajan (2011) make small modifications to the Brissimis *et al*. model, and use it to estimate sterilisation and offset coefficients for various Asian economies covering the 2000s. Some other studies follow simple money demand type specifications in the choice of control variables, for instance Aizenman and

[1] A monetary policy action through ΔNDA leads to changes in domestic interest rates which affect capital inflows and therefore, ΔNFA.

Glick (2009) who estimate sterilisation coefficients for several Asian and Latin American economies. Where large samples of countries are involved, the analysis can be fairly rudimentary, such as the bivariate static regressions of ΔNDA on ΔNFA in Cardarelli *et al.* (2009). The empirical findings across the studies generally point to a fairly high degree of base money sterilisation.

The narrative provided by the recent empirical work on the extent of sterilisation is open to criticism on three accounts. First, most studies continue to assume that ΔNDA is the policy instrument when in reality many countries have shifted from monetary-targeting to interest rate-targeting. As pointed out by Disyatat (2008), the meaningfulness of equation (1.1) is thus questionable when liquidity, regardless of the source, is absorbed to the extent that is necessary to maintain the target interest rate level. Furthermore, as we will show, with base money consisting only of currency in circulation, required and excess reserves, β will inevitably be high unless reserve requirements are actively used or if there is a deliberate policy of base money expansion.

Second, there is hardly any consideration of how foreign exchange intervention affects broad money. This is true even for the older empirical studies on sterilisation. Mohanty and Turner (2006) suggest that the sector from which liquidity is absorbed – whether banks or non-banks, determines the completeness of sterilisation. Although the authors do not state as such, their definition ties in with broad money sterilisation.

Third, the estimation of sterilisation coefficients tends to be disconnected from the analysis of the wider implications of varying degrees of sterilisation. Base money sterilisation coefficients that are estimated with econometric rigour are seldom related to wider macroeconomic outcomes; while in some of the literature that discusses the challenges of managing capital flows (for example Reinhart and Reinhart (2008), and Cardarelli *et al.* (2009)), the sterilisation coefficients are estimated in a simplistic manner and appear incidental to the analysis.

We view all three accounts as symptomatic of the lack of an underlying conceptual framework that considers how balance of payments flows and intervention affect base money and broad money, and permeate the economy. Argy and Kouri (1974), Argy and Murray (1985) and Frankel (1994) provide useful conceptual frameworks of how returns on assets are affected depending on the nature of disturbances (recognising differences in money demand and money supply shocks), and the sterilisation response, albeit only Frankel makes the distinction between narrow and broad sterilisation. However, recent empirical works appear detached from these studies. Consequently, there is a misunderstanding of the consequences, or lack thereof, of sterilisation; as well as a misrepresentation of different monetary policy frameworks, particularly in pooled and simple panel data analysis.

1.2 RESEARCH OBJECTIVES AND CONTRIBUTION

The research objectives of this thesis are to:

i. Provide a simple theoretical model for discussing the optimal monetary policy reaction function for a stylised emerging market economy, given a set of structural equations for the economy, the policy instrument is a short-term interest rate, and the central bank carries out sterilised intervention.

ii. Provide a simple conceptual framework to illustrate how balance of payments flows, foreign exchange intervention and sterilisation affect base money and broad money.

iii. Investigate the effects of foreign exchange intervention on base money and broad money for a sample of countries, and identify country characteristics that may explain these effects.

This thesis aims to contribute to the research on sterilisation of foreign exchange intervention on both the theoretical and empirical fronts. As far as we know, there is no theoretical framework that merges the portfolio balance approach to sterilisation with an interest rate reaction function, whilst recognising the distinction between base money and broad money sterilisation. We explicitly take into account the difference between sterilisation at the banks' level and sterilisation at the non-bank private sector level.

Empirically, we extend the current literature by providing detailed analysis for a reasonably large and diverse group of countries, supported by a thorough conceptual framework and without oversimplifying the econometric analysis. There are only a few existing studies that cover a large group of countries, and these tend to use comparatively simple empirical approaches. We carry out multivariate dynamic regression analysis on an individual-country basis. Crucially we devote equal attention to base money and broad money sterilisation. The empirical analysis on broad money sterilisation represents a clear departure from existing literature which has an emphasis on base money sterilisation.

1.3 THESIS OUTLINE

The rest of the thesis is organised as follows. In Chapter 2, we provide a literature review. The topics covered are the definition of sterilisation, the main strands of approaches to measuring sterilisation, and the macroeconomic effects of sterilisation. In Chapter 3, the first of our three main chapters, using a simple theoretical model of a stylised economy, we derive an optimal monetary policy reaction function that shows how the policy interest rate responds to various exogenous factors given varying degrees of broad money sterilisation. The standard aggregate demand curve is augmented with a term to capture broad money growth. We explore the literature on the role of money in modern models to support this inclusion, and largely draw on the argument put forth by Meltzer (1995, 1999). This argument states that money serves as proxy for yields on other financial and real assets which are important for economic activity. The short-term policy interest rate is not a sufficient summary of these wider monetary and financial conditions.

In the baseline model, changes in broad money are assumed to be driven by foreign exchange intervention. With a portfolio balance framework, we show that incomplete broad money sterilisation, when intervention is a positive money supply shock, leads to looser monetary and financial conditions. This in turn, entails a higher policy interest rate in the monetary policy reaction function. However, the central bank faces a dilemma as an increase in the policy interest rate would lead to further capital inflows. Such a scenario may warrant a change in the exchange rate policy or the use of alternative policy instruments. An important illustration in this chapter is the difference between base money sterilisation and broad money sterilisation. Even if there is base money sterilisation, with liquidity absorbed from banks, balance of payments flows and intervention will still permeate the economy through changes in broad money. Thus, broad money sterilisation is what matters.

In Chapter 4, we take a step back from Chapter 3 and analyse the mechanics that account for the effects of intervention, or lack thereof, on base money and broad money respectively. We lay the conceptual foundations for the empirical analysis of the effects of foreign exchange intervention on the two money variables, and explore issues related to econometric methodology and data measurement. A main hypothesis is that the effects of intervention on broad money are expected to be more variable and statistically significant than its effects on base money, depending on the types of balance of payments flows and the sectors involved, sterilisation methods, and the monetary policy stance. We make a distinction between short-run and long-run effects, the latter capturing the indirect effects on broad money growth generated through credit creation by banks and government spending. We hypothesise that intervention and reserve accumulation associated with current account and capital account surpluses of the non-bank private sector will likely have relatively significant positive short-run and indirect effects on broad money growth. The effects may be mitigated if sterilisation occurs at the non-bank private sector level; there is monetary tightening including through required reserves which limits the indirect effects; or if foreign exchange swaps have been used, as these would break the link between intervention and broad money growth.

For the specification of our two econometric models, with real base money growth and real broad money growth as the respective dependent variables, we combine the monetary approach to the balance of payments with behavioural money demand analysis in the choice of control variables. Such an approach avoids the explicit treatment of either base money or broad money as the monetary policy instrument. We use the autoregressive distributed lag (ARDL) approach which allows us to estimate contemporaneous and long-run effects of intervention on the two money variables. Our sample of 30 countries comprise 24 emerging market economies across Asia (10 countries), Latin America (six countries), Europe, the Middle-East and Africa (eight countries, cumulatively); and six developed economies.

In Chapters 5 and 6, our remaining two main chapters, we carry out the individual country regressions to estimate the effects of real intervention on real base money growth and real broad money growth respectively. We then compare the coefficients on real intervention effects against country characteristics by way of mean and median equality tests and simple bivariate regressions. The country characteristics are in terms of region; intervention volatility and reserve accumulation; income levels; current account and capital account openness and net positions; exchange rate flexibility; and monetary policy frameworks - whether the countries are inflation-targeting or non-inflation-targeting. Empirical analyses consist of the baseline scenario and robustness checks.

The results in Chapter 5 reveal that, on average, the real intervention effect on real base money growth is low, with baseline group average short-run and long-run coefficients of 0.075 and 0.111 respectively (excluding outliers: Egypt and Taiwan). For a subset of countries with relatively high coefficients, these can be related to the use of reserve requirements and monetary deposit auctions; and unique monetary policy frameworks – quantitative easing in Japan, and a currency board in Hong Kong. There are only a few instances of statistical significance in terms of the differences in country characteristics. There are robust differences in capital account openness but not of a monotonic ordering to match the monotonic ordering of the coefficients on real intervention effects.

In Chapter 6, we find that on average, the real intervention effect on real broad money growth is higher than the effect on real base money growth. The baseline group average short-run and long-run coefficients are 0.122 and 0.496 respectively (excluding outliers: Egypt and Taiwan). Equality tests and correlation analysis indicate that there is no relationship between the effects of real intervention on real base money growth with its effects on real broad money growth. Similar to the case of real base money growth, there are only a few instances of statistical significance for the relevance of country characteristics to differences in real intervention effects. We observe a tentative link between intervention volatility and intervention effects on real broad money growth, but not between the latter and reserve accumulation. There are indications that higher short-run real intervention effects on real broad money growth are associated with current account surpluses (and correspondingly capital account deficits) of a monotonic ordering. For the long-run real intervention effects, there is even less evidence of the relevance of balance of payments characteristics, with no statistical significance of test statistics across the equality tests and bivariate regressions under the baseline scenario. Nevertheless, based on the relative strengths of the test statistics, current account and capital account openness appear to be the most likely important characteristics. As for monetary policy frameworks, there does not seem to be a difference in intervention effects between inflation-targeting and non-inflation-targeting countries. This is in contrast to the results for real intervention effects on changes in real base money, which suggest that non-inflation–targeting countries exhibit higher real intervention effects. This latter result, however, is influenced by the uniqueness of Hong Kong and Japan.

In the final chapter, Chapter 7, we summarise the key findings of the thesis and their significance to current literature. We discuss the limitations of our undertaking and areas for improvement, and suggest directions for future research. We also examine possible policy implications.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, we provide an overview of selected existing studies which explore the concept, empirical estimation and macroeconomic effects of sterilisation. At the outset, a clarification of the definition of sterilisation is required. Sarno and Taylor (2001, page 839) state that “Official exchange rate intervention in the foreign exchange market occurs when the authorities buy or sell foreign exchange, normally against their own currency and in order to affect the exchange rate.” On page 841, the authors go on to note, “Official intervention is said to be sterilized when the authorities - simultaneously or with a very short lag - take action to offset or “sterilize” the effects of a change in official foreign asset holdings on the domestic monetary base.”

Obstfeld and Rogoff (1996, page 558) explain: “Often, governments try to influence the exchange rate without changing the money supply through a financial policy known as sterilized intervention. In a non-sterilized intervention operation, the government might buy foreign currency denominated bonds with domestic currency. To “sterilize” the first step of this intervention, the government reverses its expansive impact on the home money supply by selling home-currency-denominated bonds for domestic cash.”

Immediately obvious is the difference in monetary aggregates being referred to – with Sarno and Taylor focussing on “monetary base” and Obstfeld and Rogoff using the term “money supply”. Nevertheless, in a slightly more detailed exposition through pages 597-599 of their book, it becomes evident that Obstfeld and Rogoff view the term as interchangeable with monetary base: “...the central bank “sterilizes” the effects on the monetary base by selling a corresponding quantity of home-currency-denominated bonds to soak up the initial currency increase” – (page 599).

Frankel (1994) makes the distinction between sterilisation, defined broadly, where offsetting policy actions are taken to keep aggregate money supply unchanged, and a narrower definition where policy actions namely open market operations are conducted to leave the monetary base unchanged. The central bank practice of keeping a quantity, whether base money or a broad monetary aggregate unchanged is, however, generally associated with a monetary-targeting framework. In contrast, when the interest rate is the monetary policy instrument used to achieve inflation and output stabilisation goals, there may not be deliberate actions to restrain money growth to a certain level. Sterilised intervention is then, as Hutchinson (2003, page 1) states, when "the central bank offsets the purchase or sale of foreign exchange by selling or purchasing domestic securities so as to keep the domestic interest rate at its target." It is important to note that this domestic interest rate target is typically a single short-term interest rate in the interbank money market.

These definitions indicate that sterilisation is a tool to insulate domestic liquidity and monetary policy from foreign exchange market intervention. The issue arises as to whether these definitional differences have material implications when one evaluates the completeness and consequences of sterilisation. Several questions, from empirical and theoretical perspectives, can be raised as follows:

(a) How is the degree of sterilisation measured, and what does empirical evidence say about the extent of sterilisation?
(b) Can an economy fulfil the criteria of the narrow sterilisation definition but fail that of the broad definition of sterilisation?
(c) What are the effects of sterilisation on monetary and financial variables under different monetary policy frameworks and sterilisation methods?
(d) How autonomous is monetary policy with sterilisation?

Clearly a complete understanding of the dynamics of intervention and sterilisation, and monetary policy implementation is required to answer the questions above. In the context of existing literature related to sterilisation, four broad strands can be identified. The first and second have a greater consideration of theoretical underpinnings to support empirical estimation, the third is mostly empirical tests of the degree of sterilisation, and the fourth attempts to examine the consequences of reserve accumulation.

The first relatively large strand from the 1970s and 1980s expands on a financial model of the economy and elaborates on asset market (normally money and bond) equilibrium conditions. A primary focus is estimating the offset equation, the extent to which a monetary policy action is offset by a balance of payments effect, and represents a gauge of the degree of financial market integration. The offset coefficient is derived from structural estimates of asset demand functions and capital flow equations, or through reduced-form equations. Typically an equation is derived which relates the capital account to changes in the central bank's net domestic assets (ΔNDA), which is assumed to be the monetary policy instrument, and other exogenous variables. The sterilisation equation or monetary policy reaction function tends to be set up separately or sometimes as part of a system of simultaneous equations, but the choice of explanatory variables can be quite arbitrary.

The second strand attempts to present a unifying theoretical framework to estimate offset and sterilisation equations and has as its base a central bank loss minimisation function. This strand attempts to address the somewhat *ad hoc* specification of the monetary policy reaction function and some of the possible misspecification issues of the first strand evident in insignificant or perceived wrongly signed variables.

We present these strands in turn, and detail the results of selected empirical studies in *Appendix 1: Selected Recent Studies on Sterilisation in Developing Countries*. The selected studies represent key references which we return to in later empirical chapters.

2.2 EQUILIBRIUM IN ASSET MARKETS APPROACH

Argy and Kouri (1974) show theoretically that different sterilisation policies can have different economic effects in terms of the volatility in income and international reserves. The authors evaluate the effect of sterilisation based on three different rules with regard to ΔNDA. This is done by "manipulating a Keynesian-type model of an open economy", represented by the following equations, in the context of a narrowly pegged exchange rate regime. The asset market equilibrium conditions and wealth constraint are standard in studies on sterilisation which employ the combined monetary approach to the balance of payments and portfolio balance model.

$$\mathrm{Y} = \mathrm{A}(\mathrm{Y}, \mathrm{R}, \mathrm{a}) + \mathrm{X} - \mathrm{M}(\mathrm{Y}) \tag{2.1}$$

income determination equation;

domestic expenditure, A, is a function of income, interest rate and a disturbance term

$\Delta NFA = X - M(Y) - \Delta B^f$: balance of payments identity (2.2)

$Mo^d = L(W, Y, R, R^*, 1) = Mo$: demand for and supply of money (2.3)

$B^d = H(W, Y, R, R^*, 1) = B$: demand for and supply of domestic bonds (2.4)

$B^f = J(W, Y, R, R^*, 1)$: demand for foreign bonds (2.5)

$Mo^d + B^d + B^f = W = Mo + B + B^f$: wealth constraint (2.6)

$\Delta Mo^d = \Delta NDA + \Delta NFA$: change in money supply (2.7)

$\Delta NDA = -\Delta B$: open market operations (2.8)

$Y =$ income
$R =$ domestic interest rate
$R^* =$ foreign interes rate

$L_w + H_w + J_w = 1$: Domestic residents' wealth is apportioned between three assets – base money, domestic bonds and foreign bonds.

$L_i + H_i + J_i = 0, i = Y, R, R^*, 1$: Any increase in the demand for money must be identically equal to the decreases in the demand for domestic and foreign securities.

The three alternative rules are:

1. $\Delta Mo = \Delta NFA$, with NDA fixed, implying no sterilisation,
2. $\Delta Mo = \Delta NFA + \Delta NDA = 0$, implying complete sterilisation, and
3. $\Delta R = 0$, which holds domestic interest rates fixed,
   with possibly partial sterilisation.

The authors explore the impact of disturbances to a, X, Mo^d, and R^* on the volatility of international reserves, domestic interest rates and income, by working out impact multipliers. For all disturbances, the authors find that the volatility of reserves is greater with sterilisation than without. "Where the money supply is allowed to respond to developments in the balance of payments there is a partial self-adjustment at work which is absent when sterilization policies are implemented" (page 214).

The effects of sterilisation on the volatility of income, however, depend on the type of disturbance. The authors assess these effects through the impact of sterilisation on interest rates which would either have an expansionary or contractionary impact on income. Changes in expenditure, which occur when financial integration is high, and changes in exports are more stabilising on income with sterilisation than without. As the central bank intervenes, in the absence of sterilisation, the resulting effects on money supply and interest rates lead to greater variability in income.

The authors show that it is a different case with money demand shocks. An autonomous increase in money demand reduces the demand for domestic and foreign securities, the former driving up domestic interest rates. An inflow of capital is induced, which to some extent accommodates the increase in demand for money. By (completely) sterilising the inflows of capital, domestic interest rates remain relatively higher, and the effects on income tend to be larger than without (full) sterilisation. Hence a case for incomplete sterilisation can be made in the face of money demand shocks.

A rise in foreign interest rates, meanwhile, may induce shifts out of both money demand and domestic securities. As long as the central bank offsets the effects of the shifts out of domestic securities, the domestic interest rates does not rise, and there are no adverse effects on income. However, by sterilising the effects of shifts out of domestic money, the authorities force the public to hold unwanted money at the original interest rate. Hence, the domestic interest rate declines.

Thus, the authors conclude that complete sterilisation while almost certain to moderate fluctuations in income is not necessarily more stabilising to income than a fixed interest rate policy. If fluctuations in expenditure (including shifts in export) are more important than fluctuations in the demand for money and foreign interest rates, then a money supply rule is likely to be more stabilising then an interest rate rule. This result bears similarity to that of the instrument choice problem discussed in Poole (1970), where in a stochastic setting, if there are more money demand shocks than aggregate demand shocks, the interest rate should be used as the monetary policy instrument.

In a practical context, it may be difficult to identify money demand shocks and for a central bank to alternately choose between a money supply rule and an interest rate rule in its sterilisation response. Nevertheless, given widespread instability in empirical estimations of money demand, in reality many central banks in more recent times have chosen to target interest rates by default. Operationally, central banks tend to target a very short-term interest rate, relying on effective transmission to the rest of the spectrum of interest rates in order to meet their stabilisation goals. Thus, many central banks do in fact practise a fixed interest rate policy for sterilisation, at least in terms of a short-term interest rate.

Argy and Kouri's theoretical exposition of the effects of sterilisation policy illustrates the importance of asset market portfolios and the nature of disturbances affecting an economy. There are, however, several simplifications that result in some degree of ambiguity in assessing the effects of sterilisation. For instance, only base money demand is considered and implicitly a money multiplier of one is assumed. In addition, non-residents and banks are excluded from the model. One can endeavour to trace out how the dynamics between the different sectors of the economy – the non-bank private sector (foreign and domestic), the banking sector and the central bank, affect base money, broad money and asset returns.

Argy and Murray (1985) examine the effects of sterilising different types of balance of payments surpluses on domestic yields, namely bond and equity returns. This is done through a multiple-asset portfolio balance model, and with full sterilisation defined as keeping base money unchanged. With full sterilisation, bond returns are shown to rise under the scenarios of an exogenous inflow of capital, a current account surplus and a fall in foreign interest rates, while the effect on equity returns is ambiguous. Their model serves as a key reference in our simple model set-up in Chapter 3 and we therefore, discuss further details later.

Aside from the theoretical model, Argy and Kouri (1974) also estimate a system of simultaneous equations with net capital inflows and ΔNDA as dependent variables in each regression respectively, to gauge offset and sterilisation effects in Italy, Netherlands and Germany for the period 1964-1970. The two-stage least squares method is used on quarterly data to address the bias arising from the endogeneity of net capital inflows and ΔNDA. The control variables in the sterilisation equation comprise the capacity utilisation rate, a time trend and seasonal dummies. The authors' results suggest that capital flows have partly offset the effects of monetary policy on the monetary base and that sterilisation policies have been pursued but not to the full amount of payment surpluses or deficits. The authors, however, note that the results ought to be interpreted with caution, particularly the sterilisation equation which, at best, is a rough approximation to central bank behaviour.

Herring and Marston (1977) investigate the trade-off between monetary autonomy and control over foreign exchange reserves. They provide a simple model-based approach to understanding the degree of offset – the extent to which a policy-induced change in bank reserves is offset by capital flows, and estimate offset and sterilisation coefficients for Germany. Key elements that distinguish their work include the explicit introduction of the supply and demand for bank reserves that determine the domestic interest rate, and a consideration of various policy instruments in their version of the monetary policy reaction function.

The supply of bank reserves is positively related to the domestic interest rate in a fixed exchange rate regime, since higher interest rates trigger inflows, and therefore foreign exchange intervention. The demand for bank reserves meanwhile is a proportion of bank deposits based on the required reserves ratio. Since the demand for bank deposits is negatively related to the home interest rate, so is the demand for bank reserves. The demand and supply of bank reserves together determine the level of bank reserves and the interest rate on home bonds. The supply of bank reserves is determined by the quantity of foreign exchange reserves and home bonds held by the central bank (open market operations).

A policy-induced contraction in bank reserves leads to higher interest rates, which triggers inflows. To maintain a fixed exchange rate, however, an expansion in bank reserves is required. Thus only a fraction of the initial contraction takes place. The degree of offset depends positively on the ease of substitutability between foreign bonds and home bonds. It depends negatively on the interest rate sensitivity of the demand for bank deposits and the required reserves ratio. Nevertheless, if foreign exchange reserve flows can be sterilised, a high offset coefficient does not necessarily imply the loss of monetary autonomy.

The authors explain that if the central bank was exclusively committed to the attainment of domestic targets, it would sterilise completely. If the central bank was only concerned about external balance, the central bank might permit changes in foreign reserves to be fully reflected in bank reserves. "Sterilisation thus has opposite effects on capital flows and bank reserves. If sterilisation is increased to reduce the impact of capital flows on bank reserves, a price must be paid since capital inflows induced by a disturbance are thereby increased. As a result, choosing a sterilisation policy implicitly involves choosing a point on the trade-off between control over foreign exchange reserves and control over bank reserves" (page 336).

Herring and Marston estimate a monetary policy reaction function for Germany over the period 1960q3 – 1971q1. In deriving the monetary policy reaction function, the change in the monetary policy instrument is defined as the sum of the effective change in non-borrowed reserves and the change in borrowed reserves[2]. The effective change in non-borrowed reserves is the change in non-borrowed reserves net of swap commitments and the change in required reserves due to a change in the required reserves ratio.

$$\Delta MP_t = \Delta H_t^{md} - \Delta SW_t - \Delta Dep_{t-1}\Delta q_t + \Delta RB_t \tag{2.9}$$

ΔH^{md} = Open market operations (Change in holdings of government securities)
SW = Swap operations
Dep = Deposits
q = Reserve requirement ratio[3]
ΔRB = Change in borrowed reserves

The change in monetary policy is then related to the change in domestic target variables, $\mathbb{Z}$ and foreign exchange reserves, FXR (equation 2.10). The monetary targets are scaled by the average reserve requirement ratio to reflect the fact that when the reserve requirement is higher, it takes a proportionately larger increase in bank reserves to achieve a given expansionary effect. In the equation estimated, using two-stage least squares, the indicators used for domestic objectives are the inflation rate, the percentage change in manufacturing orders, and the change in trend income.

$$\Delta MP_t = a_1 q_{t-1}\Delta\mathbb{Z}_t + a_2\Delta FXR_t \tag{2.10}$$

Higher inflation and manufacturing orders (leading cyclical income indicator) lead to a decline in effective bank reserves, while an increase in trend income would lead to an increase in bank reserves (in order to finance the increased volume of economic

[2] The authors do not explicitly introduce the constituents of bank reserves but it can be gauged from their discussion that not unlike the US Federal Reserve system, bank reserves comprise required reserves, excess reserves, non-borrowed reserves (reflecting open market operations) and borrowed reserves (discount window operations).

[3] The authors make the distinction between required reserves that increase due to an increase in deposits and that which increase due to a change in the ratio itself.

activity). A high sterilisation coefficient of 0.9 is found indicating that the Bundesbank placed primary emphasis on the pursuit of its domestic objectives rather than on the maintenance of external balance. While Herring and Marston attempt a more refined measure of the monetary policy instrument; like Argy and Kouri, the focus is still on base money components and the domestic target variables are also set in a rather arbitrary manner.

Obstfeld (1983) also uses a portfolio balance model to illustrate intervention and sterilisation under imperfect asset substitutability. He examines whether the German Bundesbank pursued a sterilisation policy during the years 1975-1981 and if sterilised intervention had significant effects on the exchange rate. He states that even under flexible exchange rates, a conflict between internal and external objectives may arise (page 163): "Monetary expansion induces exchange rate depreciation which feeds into domestic prices and wages. This in turn, shortens the short run in which easy money can keep nominal interest rates low." Sterilised intervention then provides an independent policy instrument through which the central bank can resolve the policy conflict between domestic policies and balance of payment considerations in the short run.

With an expansionary monetary policy, the supply of high powered money increases, leading to a decline in the stock of outstanding Government debt with the purchase of bonds, and a decline in interest rates. The exchange rate would depreciate as a result. Sterilised intervention, however, would allow the central bank to lower the interest rate without affecting the exchange rate, with further bond purchases to offset its intervention activity which caused a decline in its foreign assets and high powered money.

In terms of the monetary policy reaction function for the Bundesbank, along the lines of Herring and Marston, the change in domestic credit ($\Delta\mathrm{DC}$) is defined as the increase in the central bank's net domestic assets ($\Delta\mathrm{NDA}$) minus the reserves impounded by any increase in required reserves. The latter component is calculated as:

$$[\mathrm{REQ}_{t} - \mathrm{REQ}_{t-1}].\,\mathrm{M3}_{t-1} \tag{2.11}$$

REQ = average reserve ratio; $\mathrm{M3}$ = broadly defined money stock

Obstfeld estimates a reaction function of the following form using non-linear least squares. (ΔDC) is assumed to respond to the change in reserves which excludes valuation adjustments, the current output gap (measured as the percent excess of trend output over actual output) and lagged inflation:

$$\Delta DC_t = \pi_1 \Delta NFA_t + \pi_2 GAP_t - \pi_3 INF_{t-1} + u_t \tag{2.12}$$

The estimation results support the hypothesis that the Bundesbank had used domestic credit policy to attain domestic policy objectives while engaged in sterilized foreign exchange intervention in order to influence the exchange rate. Over the period 1975-1981, the sterilization coefficient does not differ significantly from minus one, the coefficient on the output gap is positive and significant, but that on inflation is insignificant.

Obstfeld notes, however, that the reaction function captures the central bank's behaviour but does not necessarily indicate the efficacy of policies. Specifically, he uses a structural model of asset markets and prices with simulation experiments to gauge the effects of sterilised intervention on the exchange rate. His experiments indicate that "the Bundesbank's ability to influence the exchange rate without altering monetary conditions is very limited" (page 184).

2.3 CENTRAL BANK LOSS FUNCTION MINIMISATION APPROACH

In response to the *ad hoc* specification of reaction functions and the problem of endogeneity of the monetary policy instrument and foreign exchange reserves, Roubini (1988) proposes an analytical model where the sterilisation and offset coefficients are derived from an explicit maximisation problem faced by the monetary authority. The optimal intervention and sterilisation policies are shown to be dependent on the different disturbances hitting the economy and the preference of the monetary authorities. Like other research output in the literature, Roubini considers a simple financial model of a small open economy with a fixed exchange rate. Similar to previous models, money and bond market equilibrium conditions form the basis of this model. Incomplete asset substitutability is assumed. Roubini suggests a short-term loss function with weights given to stabilising foreign exchange reserves and interest rate-smoothing.

The loss function of the central bank is written as, $L = \frac{1}{2}(r)^2 + \alpha\frac{1}{2}(R)^2$, where α is the weight placed on the foreign reserves objective (R) relative to the interest rate smoothing goal (r) in the loss function. These are the short-run objectives of the central bank. The loss function is solved with regard to the domestic credit component of base money (D), which is the central bank's policy instrument to control its two objectives, and subject to reduced-form equations for r and R, which are derived from the asset market equations. The reduced-form equations for D and R show these two variables depending only on the exogenous variables (namely foreign interest rate, domestic financial wealth (current account), domestic real income, and the stock of domestic bonds), and not on each other which is different from the standard equations found in the literature. Under different domestic and foreign exogenous disturbances, the optimal central bank response will lead to a negative (positive) correlation between movements in D and R if the central bank places more (less) emphasis on interest rate-smoothing relative to stabilising foreign exchange reserves. The assumption of imperfect asset substitutability enables the central bank to exercise some degree of control over the domestic interest rate via D (the offset coefficient is less than one).

Brissimis *et al.* (2002) also seek to address the simultaneous equation bias associated with the offset and sterilisation literature. In particular, they note that while this is partly addressed in Herring and Marston (1977) with the offset coefficient calculated based on estimates of parameters from structural equations, such an approach is limited by the possibility of misspecification and the lack of data. The authors provide a unifying theoretical framework in which both the monetary policy reaction function and foreign exchange intervention can be jointly determined. They ensure that the resulting semi-reduced equations are identified, thus enabling better estimates of the offset and sterilisation coefficients. The authors postulate the following central bank loss function:

$$L_t = \alpha(s_t - s_t^T)^2 + \beta(\Delta p_t - \Delta p_t^T)^2 + \gamma(Y_{ct})^2 + \delta(\sigma_{rt})^2 + \omega(\sigma_{st})^2 \tag{2.13}$$

The central bank seeks to minimise deviations of the exchange rate and inflation from some target levels, as well as to minimise cyclical income; interest rate and exchange rate volatility. The measure of loss in terms of exchange rate level and volatility contrasts with previous literature which measure loss in terms of changes to foreign exchange reserves. Brissimis *et al*. choose exchange rate measures as the foreign exchange reserves measure assumes that the exchange rate target is always met. The loss function is minimised by the central bank choosing foreign exchange intervention (ΔNFA) and domestic money market intervention (ΔNDA) subject to a number of constraints, in terms of inflation; cyclical income; the balance of payments and the exchange rate; interest rate volatility; and exchange rate volatility.

Inflation:

$$\Delta p_t = \mu_1(\Delta NFA_t + \Delta NDA_t) + \mu_2 \Delta p_{t-1} \qquad (2.14)$$

Inflation depends on past inflation and the change in current base money

Cyclical income:

$$Y_{ct} = \varphi_1(\Delta NFA_t + \Delta NDA_t) + \varphi_2 Y_{ct-1} \qquad (2.15)$$

Current cyclical income depends on base money and the cyclical position of the economy in the previous period.

Balance of payments and the exchange rate:

$$\Delta NFA_t = CA + \Delta NK_t \qquad (a)$$

$$\Delta NK_t = (1/c)\Delta[(s_t - Es_{t+1}) + (r_t - r_t^*)] \qquad (b)$$

$$\Delta r_t = -\tau \Delta NDA_t \qquad (c)$$

Replacing (b) and (c) into (a) and rearranging for the exchange rate gives:

$$s_t = c\Delta NFA_t - cCA + s_{t-1} + \tau \Delta NDA_t + \Delta(E_t s_{t+1} + r_t^*) \qquad (2.16)$$

r_t^* is the foreign interest. c is the degree of relative risk aversion between domestic and foreign assets. If c=0, then domestic and foreign assets are perfect substitutes and capital is perfectly mobile – any deviation from uncovered interest rate parity will lead to an infinite capital flow.

Interest rate volatility:

$$\sigma_{rt} = \theta \sigma_{rt-1} - \partial(\Delta NDA_t - d_1 \Delta NDA_t) \qquad (2.17)$$

d_1 = 2 when the money market is in surplus, 0 when the money market is in deficit. Interest rate volatility depends positively on past levels of volatility and negatively on the absolute amount of money market intervention undertaken by the central bank.

Exchange rate volatility:

$$\sigma_{st} = \vartheta s_{t-1} - \varepsilon(\Delta NFA_t - d_2 \Delta NFA_t) \qquad (2.18)$$

d_2 = 2 when there is excess demand for foreign currency (and the central bank is losing reserves), 0 when there is excess supply of foreign currency (and reserves are rising).

Solving the system of equations, semi-reduced-form equations for ΔNDA (sterilisation equation) and ΔNFA (offset equation) are derived such that:

$$\Delta NDA_t = f(-\Delta NFA_t, CA_t, -(s_{t-1} - s^T), -\Delta(E_t s_{t+1} + r_t^*), -\Delta p_{t-1}, -Y_{ct-1}, -(d_1 - 1)\sigma_{rt-1}) \quad (2.19)$$

$$\Delta NFA_t = f(-\Delta NDA_t, CA_t, -(s_{t-1} - s^T), -\Delta(E_t s_{t+1} + r_t^*), -\Delta p_{t-1}, -Y_{ct-1}, -(d_2 - 1)\sigma_{st-1}) \quad (2.20)$$

"The volatility of the domestic interest rate and the exchange rate identify the money market intervention rule and the foreign exchange intervention rule respectively. Thus, the two equations are independent of each other and it is possible to solve for reduced-form equations for both ΔNDA and ΔNFA" (page 68), though the authors do not do this in their paper.

The authors use three-stage least squares to estimate the sterilisation and offset coefficients for Germany over the period 1979-1992. In the sterilisation equation, income and inflation are found to be insignificant. The authors attribute this to inflation being more of a concern than income deviations from trend, and to ΔNDA and ΔNFA being rather volatile, which is not the case for the inflation series. The other explanatory variables are found to be significant. The long-run sterilisation coefficient for Germany is found to be not significantly different from one.

Ouyang *et al.* (2008, 2010) and Ouyang and Rajan (2011) modify the loss minimisation framework of Brissimis *et al.* (2002) in order to investigate the sterilisation and offset coefficients for eight Asian economies through panel data analysis[4]; and individually for China; and Singapore and Taiwan respectively, over sample periods that encompass the 2000s. The key changes made by the authors are dropping the deviation of the exchange rate from a target level from the loss function; endogenising the current account by assuming it is affected by both income and the exchange rate ($CA = \alpha_1 Y_{c,t} + \alpha_2 \Delta REER_{t-1}$). incorporating government spending as a factor affecting cyclical output; and having inflation and cyclical

[4] The countries in the panel data analysis are India, Malaysia, Philippines, Thailand, Singapore, Korea, Indonesia and Taiwan. According to Ouyang *et al.*, the Hausman test indicates no significant difference in the estimations using fixed and random effects. Only the empirical results of the random effects estimation are reported.

output depend positively on the change in money supply (ΔBM_t) while the interest rate is negatively influenced by ΔBM_t[5]. ΔBM_t is defined to result from changes in base money and the money multiplier: $\Delta BM_t = (\Delta NDA_t + \Delta NFA_t)mm_t + RM_t\Delta mm_t$. The authors solve the system of equations to arrive at the following semi-reduced sterilisation and offset equations:

$$\Delta NDA_t = f(-\Delta NFA_t, -\Delta mm_t, -\Delta(E_t s_{t+1} + r_t^*), -\Delta p_{t-1}, -Y_{ct-1}, -\Delta G_t, \Delta REER_{t-1}, -(d_1 - 1)\sigma_{rt-1}) \tag{2.21}$$

$$\Delta NFA_t = f(-\Delta NDA_t, -\Delta mm_t, -\Delta(E_t s_{t+1} + r_t^*), -\Delta p_{t-1}, -Y_{ct-1}, -\Delta G_t, \Delta REER_{t-1}, -(d_2 - 1)\sigma_{st-1}) \tag{2.22}$$

For the panel data analysis (Ouyang *et al.*, 2008), emprical results from two-stage least squares panel regression for pre-crisis (1990q1-1997q1) and post-crisis (1998q3-2005q3) sample periods under two alternative assumptions on the formation of exchange rate expectations indicate a lower offset (capital mobility) coefficient in the second sub-sample. The results on the sterilisation coefficient are hard to assess, rising under one scenario in the post-crisis period (and exceeding one) and declining under the other, but do suggest that the extent of sterilisation has remained high (above one in the perfect foresight model and around 0.9 in the static expectations model). Of the other explanatory variables in the regressions, the money multiplier is the only regressor displaying consistent statistical significance, with negative coefficients across sub-samples for the sterilisation and offset equations. The authors expect negative signs which are interpreted as reflecting contractionary monetary policy in the sterilisation equation in response to a rise in the multiplier, and outflows in the offset equation on account of a rise in the multiplier which expands money and pushes down interest rates.

The framework used by Ouyang *et al.* (2008) to generalise across recent experiences of several countries raises several issues, particularly since the countries are a mixture of interest rate-targeting and monetary-targeting. The authors state that

[5] In Brissimis *et al.* (2002), base money is used in the cyclical income and inflation equations while the domestic interest rate is negatively related to ΔNDA_t.

they do not attempt to specify a policy rule and hence it is reasonable to derive an equation for ΔNDA as opposed to interest rates. However, their interpretation of the coefficients on the regressors in the sterilisation equation very much treats ΔNDA as a monetary policy instrument. In particular, we would intepret the negative coefficient on the the money multipler differently – a decline in the money multiplier reflects higher reserve requirements, which, following the identity of base money components, would imply a positive ΔNDA. That is, with more liquidity absorbed through required reserves, there is less need for absorption through ΔNDA. The model also assumes a direct link between money, and inflation and cyclical income, and that the interest rate is determined by the change in money supply – all suggesting an exogenous, policy instrument role for money.

2.4 STERILISATION: A SURVEY OF OTHER RECENT EMPIRICAL CONTRIBUTIONS

More recent studies in the 1990s and 2000s tend to take a looser approach to theoretical foundations in the empirical estimation of the extent of sterilisation. The methods of estimation however are wide-ranging, from simple ratios to single-equations, simultaneous equations, vector auto-regressions (VAR) and vector error correction models (VECM). In addition, the specifications of the equations tend to vary with different explanatory variables assumed. As with previous literature, studies tend to focus on base money sterilisation rather than broad money sterilisation, and oscillate between adjusting and not adjusting for reserve requirements.

Cardarelli *et al*. (2009) develop a sterilisation index for 52 countries – eight advanced and 44 developing countries over the period 1991-2007. Pooled regressions of central banks' $\Delta\mathrm{NDA}$ on $\Delta\mathrm{NFA}$ are carried out for each year using monthly observations. There is no inclusion of other explanatory variables.

$$\Delta\mathrm{NDA}_{\mathrm{it}} = \mathrm{a}_{\mathrm{it}} + \beta_{\mathrm{it}}\Delta\mathrm{NFA}_{\mathrm{it}} + \mathrm{u}_{\mathrm{it}} \qquad (2.23)$$

The authors also estimate a broad sterilisation index, which they view as reflecting sterilisation efforts primarily through reserve requirements to prevent an increase in base money from causing a broad money expansion. The regression equation for the broad measure takes the following form:

$$\Delta M2_{it} = b_{it} + \delta_{it}\Delta NFA_{it} + u_{it} \qquad (2.24)$$

A value of $\delta = 0$ in (2.24) implies full sterilisation. The authors indicate that the results for this broad index were found to be consistent with the ones using the narrow index but do not reproduce the results and instead choose to focus on the narrow index as “it matched some country experiences better” (page 18). The authors briefly acknowledge the use of alternative measures including adding additional explanatory variables but state that they aim to “strike an appropriate balance between technical sophistication and cross-country consistency” (page 19).

Their results of the narrow sterilisation index suggest some convergence in the degree of sterilisation across regions (page 23): “The high values of the index in the early 1990s and the early 2000s-the beginning of the two waves of large capital inflows – suggest an aggressive sterilization effort when capital begins to pour in. The index subsequently tapers off around 2006, perhaps indicating that as intervention continued, the authorities became increasingly conscious of its cost.”

While the authors do not delve into specific country experiences to quantify the impact of sterilisation on monetary and financial conditions, they assert that “A policy of aggressive sterilization usually raises domestic interest rates. The standard mechanism for the increase in interest rates works as follows: to induce investors to hold increased supply of short-term paper owing to open market operations, the price of this paper need to fall and yields to increase. In other words, a decrease in central banks’ NDA leads to an increase in interest rates. Therefore, movements in short-term interest rates can be seen as counterparts of changes in central banks’ domestic assets and thus of the sterilization effort” (page 19). This would however depend on, as Argy and Kouri (1974) point out, the nature of the sterilisation policy, as well as possibly the demand for short-term paper. In addition, while Cardarelli *et al.* (2009) do not explore the mechanics of sterilisation under an interest rate-targeting framework, they note (page 19): “...the increase in the monetary base (low sterilization) may not reflect expansionary monetary policy, but simply the accommodation of a higher demand for money.”

Takagi (1999), in contrast, focuses exclusively on measuring the broad definition of sterilisation for five Asian countries (Thailand, Indonesia, Korea, Malaysia and the Philippines) over the period 1987-1997. He explains that the broad definition allows for the estimation of the degree of sterilisation whilst setting aside the question of how sterilisation has actually been carried out, since the countries in the sample have used various sterilisation methods. He carries out Granger causality tests between central bank foreign assets (FA) and monetary aggregates (M1 and M2), and the following regression, which resembles a real money demand equation:

$$\Delta \ln\left(\frac{M_t}{P_t}\right) = d + h\Delta \ln\left(\frac{FA_{t-1}}{P_{t-1}}\right) + qv_t + u_t \qquad (2.25)$$

In the above equation, v is a vector of other explanatory variables including the change in real output, the change in money market interest rates and seasonal dummies. Lagged FA is used in the estimation because it is expected to affect broad money over time through the banking sector. Overall, the causality tests and the regression analysis appear to suggest that sterilisation was effective in limiting the growth of monetary aggregates in all countries. Granger causality tests suggest no relationship running from foreign assets to money market rates, which the author notes (page 13), "may mean that sterilization was effective, not necessarily in raising the level of interest rates, but in keeping it from falling towards world interest rates."

Lavigne (2008) meanwhile computes simple ratios of ΔNDA to ΔNFA, with the former adjusted for reserve requirements, to measure "total" sterilisation. The ratios, however, still belong to the category of the narrow definition of sterilisation as the focus is on base money. The following ratios are used: $\frac{\Delta RD - \Delta NDA}{\Delta NFA}$ or, equivalently, $\frac{\Delta NFA - \Delta CC}{\Delta NFA}$. RD and CC are reserve deposits and currency in circulation respectively. These ratios are calculated for 35 countries covering emerging Asia, oil producing countries, Latin America and other emerging market economies in Europe, the Middle East and Africa. The author focuses on 2000-2006 with 1990-1996 as a reference period, noting that over the past three decades, the latter has been the only other major instance of protracted sterilisation roughly comparable to 2000-2006. Lavigne notes however, that most of the reserve accumulation in the early 1990s was driven by capital account surpluses but over 2000-2006 most countries were running current account surpluses. Based on the analysis of ratios, sterilisation ratios have been high and there appears to be higher sterilisation over 2000-2006. We highlight, however, that Lavigne is essentially measuring the growth in currency in circulation versus reserve accumulation. The usefulness of this measure and more generally, base money sterilisation is discussed in Chapter 4.

Aizenman and Glick (2009) estimate sterilisation equations for selected countries in Asia and Latin America[6] based on the narrow definition of sterilisation. The authors attempt to analyse how sterilisation depends on the underlying source of reserve accumulation – whether net exports or different forms of capital inflows. The authors find that for some countries, the sterilisation of foreign direct investment (FDI) inflows is typically less than for current account surpluses and non-FDI flows "suggesting that misgivings about monetary instability depend on the composition of balance of payments inflows" (page 778), that is these countries are less anxious about the monetary impact of direct investment flows. However, no explanation is provided for the possible different treatment of the flows. We are of the view that it is difficult to reconcile the different treatment of flows with an interest rate-targeting framework. As long as there is intervention, the liquidity associated with such operations will be absorbed to keep interest rates stable regardless of the balance of payments source. It is then a question of whether there is more intervention for some flows relative to others. The differences in treatment that Aizenman and Glick find may instead reflect the larger-sized current account and non-FDI flows and higher associated intervention driving the regression relationship. It should be noted that no information is available on the extent of intervention that is actually involved for the different types of balance of payments flows.

Aizenman and Glick estimate the degree of sterilisation by regressing $\Delta\mathrm{NDA}$ on $\Delta\mathrm{NFA}$ (and in an alternative specification, the subcomponents of the balance of payments). The change is measured over four quarters and scaled by the level of reserve money stock four quarters ago. The four-quarter growth rate of nominal GDP is included as an exogenous variable to control for other explanatory variables, $\mathbb{Z}$, that might influence the demand for money. The authors thus do not model the regression as a monetary policy reaction function.

$$\Delta\mathrm{NDA}_t/\mathrm{RM}_{t-4} = a + \beta\Delta\mathrm{NFA}_t/\mathrm{RM}_{t-4} + \delta\mathbb{Z}_t + u_t \qquad (2.26)$$

[6] The countries in the authors' sample are: China, India, Korea, Malaysia, Singapore and Thailand in Asia; Argentina, Brazil and Mexico in Latin America.

The equation is estimated for each country with OLS over sample periods that end 2007q2 but have varying start points in the 1980s or 1990s. The coefficient on nominal GDP growth is positive, "implying that the central bank supplies liquidity to the economy by increasing its claims in response to greater economic activity" (page 784). The authors also estimate the equation with inflation and real GDP growth instead. The coefficients on these variables are found to be generally positive and significant, consistent with the positive sign on nominal GDP. We note that these results are different from other studies in that the coefficients are significant, and the positive signs are in fact the expected signs. In contrast, in a monetary policy reaction function, negative signs on the coefficients for inflation and output gap would be expected.

2.5 MACROECONOMIC CONSEQUENCES AND LIMITS OF STERILISATION

In the previous sections, we mainly dealt with the definition and measurement of sterilisation. We found that research focus has generally been skewed towards base money sterilisation and that there is no consensus, empirically, on the method to estimate the degree of sterilisation.

We also partly covered the question of how monetary and financial variables evolve amidst sterilisation, mainly drawing on Argy and Kouri (1974) who theorise that the effects of sterilisation on interest rates depend upon the nature of shocks and the extent of sterilisation in response to these shocks. Argy and Murray (1985) show that if changes to base money are fully sterilised, bond returns will unambiguously increase under different positive balance of payments shocks.

Frankel (1994), with reference to broad money sterilisation, also states that the desirable strategy in the treatment of capital inflows depends on the nature of the disturbances. For instance, when there are shifts in preference from foreign bonds to domestic bonds, driven by either external or domestic factors, such as market reform, there is a case for sterilising these flows by supplying the domestic bonds to meet investors' demand. When instead, there is an increased demand for money, for example in response to an exchange rate stabilisation programme, there should not be an attempt to sterilise the increase in money. He notes however, in a situation with multiple assets, if there was increased demand for corporate bonds and equities and central bank securities were poor substitutes for these other assets, then interest rates on the sterilisation bonds may increase whilst the returns on the other assets decline[7].

Cardarelli *et al*. (2009) note that it is generally expected that sterilisation would lead to a rise in interest rates[8]. Takagi (1999) however, found evidence to the contrary. In this section, the macroeconomic consequences of reserve accumulation and sterilisation are taken up more comprehensively, along with the practical limits and challenges associated with carrying out sterilisation.

At the crux of the matter is whether central banks are still able to achieve their domestic stabilisation goals and, given lags, how reserve accumulation and sterilisation affect elements that may have implications for the achievement of these goals in the medium to long run. These elements would include the degree of monetary policy independence (being able to influence interest rates towards attaining domestic goals; and the degree of correlation with global interest rates), the relative accommodativeness of monetary conditions (changes in the spectrum of interest rates and prices on other financial and real variables) and the effectiveness of the monetary transmission mechanism. There appears not to be a single piece of literature that brings all these elements together, although there are various studies that have addressed these issues separately[9].

Reinhart and Reinhart (1998) explore the effects of sterilised intervention on interest rates, spreads and capital flows in several episodes of large inflows including

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7 Frankel (1994) argues that the contrasting views of Calvo *et al.* (1993) and Reisen (1993) are both correct under different circumstances. The Calvo *et al.* view is that sterilisation perpetuates a high domestic-foreign interest rate differential and increases the fiscal burden (in a primarily Latin American context). Reisen points to the more successful sterilisation efforts in South-East Asia compared to Latin America. Frankel attributes the differences to the nature of disturbances to reserve inflows. In particular, he suggests that only with an increase in the demand for money, or an increase in demand for domestic goods is the interest rate higher with the disturbance then without it. As for the relatively more successful sterilisation in South-East Asia, he suggests that the countries in question may have been able to retain the ability to sterilise while undertaking international financial liberalisation because domestic financial liberalisation was delayed, such that it was not the domestic interest rate that mattered most for domestic demand.

8 Cardarelli *et al*. (2009) find that greater real exchange rate appreciation has been associated with stronger acceleration of CPI inflation, more sterilised intervention and rising government expenditure. These results are taken to indicate that a policy of sterilised intervention is unlikely to prevent real appreciation and often tends to be associated with higher inflation. Increasing quasi-fiscal costs of sterilisation may eventually induce policymakers to give up complete sterilisation efforts. The additional liquidity from incomplete sterilisation may then add to inflationary pressures.

9 We note that there has been substantial debate on the effectiveness of sterilised intervention in terms of influencing exchange rates, generally with evidence of short-term influence but questionable persistent effects. See, for instance, Sarno and Taylor (2001) and Disyatat and Galati (2005) for overviews, and Siklos and Weymark (2007) for empirical analysis in the context of emerging market economies. We do not focus on this aspect of the sterilisation literature, but rather assume that central banks, particularly in emerging market economies, are able to influence exchange rates given evidence of active intervention operations and reserve accumulation.

those in Chile (1990), Colombia (1991), Indonesia (1991-1992), and Malaysia (1991-1993). They highlight that six empirical regularities characterise these episodes:

(1) A considerable amount of international reserves were accumulated.
(2) Despite heavy foreign exchange intervention, either the rate of exchange rate devaluation slowed or there was a revaluation.
(3) Issuance of central bank notes increased dramatically.
(4) Domestic short-term interest rates (deposits, prime loan rates, and central bank paper) rose when sterilisation began. This may support the imperfect asset substitutability argument of Frankel (1994). In addition, since capital inflows may coincide with periods of strong economic growth, it is possible that money demand also increased. As such, monetary policy may have been inadvertently tight, in that increases in money demand were not accommodated.
(5) Interest rate spreads were kept high by sterilisation policies. Sterilisation policies were either abandoned altogether, scaled back, or complemented by capital controls, as it became evident that the high domestic interest rates were attracting more inflows.
(6) In addition to attracting further short-term flows, the rise in short-term interest rates associated with sterilised intervention dampened investment demand when sustained for a sufficient period. That is, as a result of the intervention, holding all else equal, the cost of capital rose with the returns on less risky assets (such as government paper).

Reinhart and Reinhart's conclusions illustrate how sterilisation can lead to increases and variability in interest rates which may be undesirable from the standpoint of domestic goals[10] and also self-defeating in that it reinforces capital flows. It would also seem that while imperfect asset substitutability between foreign and domestic assets is necessary for sterilisation to work, imperfect asset substitutability between domestic assets or the mismatch between assets supplied (by central banks) and demanded (by investors) could be detrimental to the effectiveness of sterilisation. Thaicharoen and Ananchotikul (2008), in discussing the challenges

[10] Reinhart and Reinhart, however, do not clarify if indeed, the interest rates were deliberately increased to reflect the general monetary tightening stance at the time. Further, Takagi (1999)'s results appear to contradict Reinhart and Reinhart as the former does not find that a rise in foreign assets leads to a rise in interest rates, though this may reflect the differences in interest rates considered and the sample period.

faced by Thailand that led to the imposition of unremunerated reserve requirements in December 2006, also highlight the difficulty of carrying out large scale intervention and sterilisation with regard to interest rates. They note (page 439): "...too many bond issues bunching up together in a short period of time could have an adverse impact on the yield curve. Special attention was therefore paid to the timing, volume and maturity of the bond issues, in order to minimise the impact".

Mohanty and Turner (2006) explore how prolonged reserve accumulation and sterilisation can lead to other adverse consequences even if near-term inflation is not readily apparent. These include monetary imbalances; overheated asset markets; distortions and reduced efficiency in the banking system which could affect financial intermediation; and balance sheet losses for central banks.

The authors highlight that large scale reserve accumulation typically raises the underlying liquidity position of the banking system. "This can be partly neutralised by selling long-term government bonds to banks. If such bonds are then sold to non-banks, sterilisation can be thought to be reasonably complete: households or non-bank firms lower their holding of monetary assets and increase that of non-monetary assets such as government bonds" (page 47). Focusing on the period 2000-2006, the authors find that among a number of emerging market economies, sterilisation debt securities are often of short-term tenures and mostly held by banks. If banks with such liquid assets "feel better placed" to expand credit, then the restraining influence of sterilised intervention could prove temporary, and there could be excessive credit growth and investment in asset markets. The authors highlight easier financing conditions with particularly sharp lending to the property sector, across some emerging market economies in the post-crisis period roughly up to 2005. Additionally, there has been rapid growth in equity prices in some countries.

The authors define complete sterilisation conditional on the use of long-term bonds based on Kumhof (2004). Kumhof presents a formal micro-founded model to explain why higher interest rates need not reduce inflation during episodes of capital inflows. The basis of Kumhof's theoretical model is that short-term sterilisation bonds have monetary characteristics and can often be used to settle large transactions. Households' holdings of bank deposits and government bonds both then serve transaction purposes. Lower foreign inflation reduces the opportunity cost of domestic assets and the price of consumption of tradables, which lead to capital inflows and a current account deficit. Temporarily higher interest rates raise the relative opportunity cost of deposits but not the overall opportunity cost of domestic liquidity (deposits and bonds) versus foreign bonds.

In terms of implications for financial intermediation, Mohanty and Turner suggest that prolonged sterilised intervention could alter the behaviour of banks as easy profits from investing in sterilisation securities could weaken the pressure for banks to become more efficient. Meanwhile the use of reserve requirements may encourage financial disintermediation while direct credit controls compromise the efficiency of resource allocation. In the authors' choice of sample period, they found that there was still relatively limited use of non-market instruments.

From the perspective of the central bank's balance sheet, the use of short-term securities increases the central bank's exposure to future interest rate fluctuations. Strong demand for risk-free assets by banks appeared to have helped central banks avoid large increases in sterilisation costs, but if this was to reverse, market based sterilisation could become more difficult and costly. The authors point to concerns raised by the Bank of Korea in 2005 about rising interest costs. In terms of carrying costs (the difference between the average return on central bank liabilities and that earned on foreign assets), approximated in June 2006, more Asian economies experienced negative carrying costs as compared to Latin American countries. The authors note this carrying cost is dependent on the interest rate cycle.

Another effect of large reserve accumulation on the central bank balance sheet is potential valuation losses arising from currency appreciation. However, "it is debatable how far valuation losses might matter for the sustainability of intervention policy. The direct economic consequences might be limited...Valuation losses might matter however, if they were to undermine a central bank's credibility or independence" (page 46).

Ooi (2008), in detailing Malaysia's more recent experience in managing capital flows, provides counter-arguments to Mohanty and Turner's discussion of sterilisation leading to banks holding highly liquid assets and making easy profits. In terms of instruments used by the central bank, Ooi notes that while direct (uncollateralised) borrowing clearly leads to an increase in banks' liquid assets, the effect of issuing monetary notes/securities is less straightforward as not all the securities are taken up by banks. A substantial portion has instead been taken up by non-residents. Ooi also states that the perceived incentive to reap easy profits from the sterilisation securities may be overstated. “In practice, banks find it more profitable to invest in other assets given larger risk premiums embedded in loans and non-sterilisation papers. In fact banks in Malaysia have been competing with each other to increase lending, amid ample liquidity, on price and non-price factors...” (page 336).

Ho and McCauley (2008), also attempt to analyse the extent to which the adverse domestic consequences associated with reserve accumulation, in terms of monetary control and central bank balance sheet risks, have actually materialised. Their focus is on 13 countries in the Asia Pacific over the period 2002-2006, and thus the authors note that their findings may differ from Mohanty and Turner (2006), who focus on a larger sample of economies. Monetary control is assessed in terms of successful technical sterilisation[11], whether inflation goals have been compromised and trends in credit growth. Technical sterilisation is assessed in terms of central banks’ meeting their announced operating targets and the extent of base money growth. The authors find that central banks[12] with explicit short-term interest rate operating targets or official rate corridors were able to manage money market liquidity such that the relevant interest rates did not fall and stay below their announced targets or their relevant lower bounds. “It is also notable that even though quantities are in principle endogenous in interest rate-targeting economies such as Korea, Malaysia, Taiwan and Thailand, liquidity draining operations nonetheless managed to constrain their economies’ base money growth as evidenced from the large gaps between net foreign asset growth and base money growth...Thus, in both price and quantity terms, sterilization was technically effective in these economies, and monetary control at the operational level remained intact”. The authors indicate that the case of China is difficult to interpret as the central bank’s monetary operation

[11] Ho and McCauley recognise that in practice many central banks define their operating targets in terms of a short-term interest rate, leaving quantities endogenous. The liquidity eventually absorbed would depend on (1) the net liquidity position of the system after taking into account all autonomous factors and (2) the central bank’s operating objective. “Thus sterilization is in practice more an interpretation rather than a separate policy: sterilized intervention can be said to have occurred if the surplus liquidity that is being mopped up originates predominantly from foreign exchange purchases.” Monetary control, as per the central bank’s operational goal, does not require fully sterilising each unit of foreign exchange purchase. The automatic offsetting liquidity operations in an interest rate-targeting framework are also discussed by Disyatat (2008) who covers various misconceptions about the implementation of monetary policy.

[12] This includes India, Indonesia, Korea, Malaysia, the Philippines, and Thailand.

goals are not explicitly stated. Nevertheless, they draw on the results of Yu (2008) and Hong Kong Monetary Authority (2008) which suggest that large amounts of excess liquidity have been absorbed through reserve requirements.

In terms of the effects on inflation, Ho and McCauley (2008) find no apparent link to reserve accumulation. Though inflation was less than benign in China and India, there is in fact an inverse relationship between reserve accumulation and average inflation performance in Asia over the period 2002-2006. The top reserve accumulators all had relatively low inflation or deflation. In contrast, two economies that saw the least reserve accumulation (Indonesia and the Philippines), given currency weakness through 2005, were the ones that overshot inflation targets and experienced the highest inflation in the region. The authors state that the heavy intervention in Asia in the early 2000s might be seen as reflecting the macroeconomic slack prevalent in the Asian economies.

In the absence of goods price inflation, the authors also examine credit growth. "If intervention, even if sterilised, created looser-than-otherwise conditions that encouraged excessive credit growth, a kind of "overheating in disguise" would result." The authors do not find a tight link between reserve accumulation and private credit growth. In the authors' assessment, only two large reserve accumulators, Korea and India, displayed both strong credit growth and a rise in the loan-deposit ratio. Although China and Taiwan registered relatively strong credit growth in 2002-2006 compared to the other countries in the sample, their loan-deposit ratios did not increase during this period. For the sample as a whole, the change in the loan-deposit ratio exhibits a negative relationship with the extent of reserve accumulation[13]. "Such a relationship suggests that rather than being an independent policy that has a side-effect of fuelling loan growth, the heavy intervention in Asia might have been a response to the lack of loan growth."

Another aspect Ho and McCauley focus on is central bank valuation losses and quasi-fiscal costs of sterilised intervention. The authors note that while the carrying cost is significantly positive only for India, the exposure to exchange valuation losses applies more widely across the region.

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[13] Ho and McCauley run regressions of reserve accumulation against average annual inflation, change in private sector credit, and change in loan-deposit ratio (all as a percentage of GDP) respectively.

Overall, while macroeconomic slack and low interest rates may have allowed central banks to avoid the adverse consequences associated with reserve accumulation and sterilisation there could still be cause for concern in the future. In particular, the authors state that the link to asset prices merits further investigation, especially in light of the surge in Chinese equity prices in 2006 and 2007.

Ho and McCauley’s use of the loan-deposit ratio as a reassuring indicator of non-overly expansionary monetary conditions, however, may be somewhat misleading as a stable or falling ratio could reflect deposits/money growing at a faster pace compared to loans. Strong money growth may have implications for asset price increases (which the authors’ highlight have taken place) even if there were no immediate signs of goods price inflation.

The above research studies are silent on the implications of reserve accumulation on the monetary transmission mechanism, but some others do highlight the possible complications that arise from surplus liquidity. Bank of Thailand (2004) for instance, notes that a by-product of excess market liquidity is that commercial banks as a whole are net lenders in the money market. As a result, changes in short-term interest rates, which the Bank of Thailand can influence closely, do not impact directly on banks’ cost of funds but instead affect their returns on investment. In this setting, the influence of short-term interest rates on banks’ retail deposit and lending rates is somewhat diminished. “Overall, with virtually no competitive pressure for deposits but a very high degree of competition on loan extension, the existence of excess liquidity in Thailand’s financial system implies that the pass-through from short-term interest rates to banks’ retail interest rates is weaker and more drawn-out than usual” (page 37). This conclusion is supported by empirical evidence which indicates that the degree of pass-through in Thailand had fallen after the 1997 crisis.

2.6 CONCLUSION

From the literature review in this chapter, we can draw several summary observations. The conceptual framework underlying most studies assumes that the monetary policy instrument is the change in the central bank’s net domestic assets and not interest rates. The empirical estimation of the extent of sterilisation is primarily in terms of the impact of changes in net foreign assets on changes in net domestic assets or changes in base money. There is limited exploration of broad money sterilisation and whether differences, or lack thereof, with base money sterilisation have meaningful implications. Because of the absence of an underlying consistent conceptual framework, particularly with regard to more recent empirical work, some estimations follow policy reaction function specifications while others opt for money demand type specifications. In some instances, where large samples of countries are involved, only rudimentary analysis such as bivariate regressions and ratios are carried out. The empirical findings generally point to a fairly high degree of base money sterilisation.

There appears to be a disconnect between the literature that discusses the conceptual framework of monetary policy implementation and the challenges of managing capital flows including through sterilised intervention, with the studies that carry out rigorous empirical analysis of sterilisation coefficients. Recent literature that explores aspects of monetary policy implementation raises questions about the sufficiency of measuring base money sterilisation, especially in the context of interest rate-targeting, since any source of liquidity, including intervention, is absorbed to the extent that is necessary to keep the level of the policy interest rate stable. Mohanty and Turner (2006) suggest a definition of the completeness of sterilisation, which depends on the sectors from which liquidity is absorbed, although they themselves do not formally introduce a corresponding empirical measure. Once there is an explicit recognition of different sectors (namely banks and the non-bank private sector), this requires consideration of broad money sterilisation. These are issues not addressed in recent empirical work.

In terms of the macroeconomic consequences of sterilisation, Argy and Kouri (1974), Argy and Murray (1985) and Frankel (1994) provide conceptual frameworks of how returns on assets are affected depending on the nature of disturbances and the sterilisation response. The explanations provided appear to be congruent with the case studies detailed in Reinhart and Reinhart (1998) and the empirical analysis of Ho and McCauley (2008). Sterilisation appears to drive up interest rates and seems less effective under scenarios of strong economic growth/current account deficits than in situations of economic slack or benign inflationary conditions. Nevertheless, in the latter case, with the build-up of excess liquidity within the banking system, there may be adverse implications for asset prices and the monetary transmission mechanism.

The literature review exposes several gaps which we set out to address with our research. One, we provide a simple theoretical framework, with explicit recognition of the banking and non-bank sectors that shows how base money and broad money sterilisation relate to the policy interest rate. We incorporate different balance of payments scenarios which have varying effects on asset returns and therefore imply different broad money sterilisation strategies. Two, we provide a detailed conceptual framework, that is relevant to current times, to underpin the empirical estimation of base money and broad money sterilisation. In this context, we also address in further detail issues related to data definition and measurement, and empirical methodology. Three, we estimate and compare the degree of base money and broad money sterilisation across a reasonably large sample of countries using individual country multivariate dynamic regressions. We then compare these coefficients across various country characteristics to better understand the drivers of the results.

CHAPTER 3

A SIMPLE MODEL OF MONETARY POLICY WITH STERILISED INTERVENTION

3. 1 INTRODUCTION

In emerging market economies, the exchange rate is important for two key reasons. One, from the monetary policy perspective, abrupt and persistent movements in the exchange rate can have adverse repercussions for inflation when pass-through from the exchange rate to domestic prices is high, and on output, via the tradables sector. Two, exchange rate policy also matters for financial stability in countries susceptible to sudden reversals of large capital inflows and in which foreign exchange markets are relatively thin. In either case, the monetary policy response, typically by way of a short-term policy interest rate[14], to the exchange rate may depend on whether the central bank can use other instruments. As Mohanty and Klau (2004, page 214) note, "These can include not only the conventional types such as foreign exchange intervention but also less conventional ones such as temporary capital controls, debt swaps and exchange rate-linked instruments to stabilise exchange rate expectations".

On one hand, while thin markets provide a reason to intervene to avoid excessive exchange rate volatility, on the other, they also allow for effective foreign exchange intervention in emerging markets as the central bank is a large player in the market for its own currency (Engel, 2009). Thus, intervention, with effective sterilisation – successfully insulating domestic liquidity and maintaining policy independence, offers the possibility of separating exchange rate policy from monetary policy, as well as the possibility of using the exchange rate as an additional policy instrument.

[14] Based on the 21 countries that currently make up the membership of the Morgan Stanley Capital International (MSCI) index for emerging market economies, 14 have adopted the inflation-targeting framework, with most having done so post-1998. While not exclusive to inflation-targeting countries, a key element of the framework is the use of a short-term interest rate as the primary policy instrument.

There is a gap in the literature in terms of analysing sterilisation and incorporating sterilised intervention into monetary policy reaction functions, especially where present reality is concerned. Empirical studies, including those based on theoretical models, that attempt to assess the extent and effectiveness of sterilisation tend to assume the change in the central bank's net domestic assets (ΔNDA) as the monetary policy instrument. These include older studies such as Argy and Kouri (1974), Herring and Marston (1977) and Obstfeld (1983), which were reflective of conditions prevailing at the time, and newer studies such as Brissimis *et al.* (2002) which attempts a historical study of Germany over 1979-1992, and Ouyang *et al.* (2008), which though dealing with a more recent sample period (1990-2005), and eight Asian countries, also assumes ΔNDA as the policy instrument. Studies that dwell on more recent developments ought to consider more carefully the monetary policy frameworks of countries under focus, and the fact that most central banks now operate through a short-term interest rate. See for instance, Disyatat (2008, 2011) and Borio and Disyatat (2009) for discussions on the liquidity management aspect of monetary policy implementation, and in particular, the "decoupling principle", whereby a given level of the short-term interest rate, which reflects the official monetary policy stance, can be consistent with a range of quantities of banking institutions' reserves with the central bank, and therefore, ΔNDA.[15]

The focus of studies also tends to be on the narrow definition of sterilisation, comparing changes in base money (ΔRM) or ΔNDA against changes in central bank net foreign assets (ΔNFA), as opposed to the broad definition of sterilisation which compares changes in broad money (ΔBM) against ΔNFA. Sterilising broad money in fact has different implications for financial variables than sterilising base money. Mohanty and Turner (2006) suggest that the type of instruments used, and the sector from which liquidity is absorbed – whether non-bank private agents or banks,

[15] For example, Disyatat (2008) explains that the demand for bank reserves, consisting of required reserves and excess reserves, are fundamentally highly interest rate inelastic and depend on factors such as the size of reserve requirement, uncertainty regarding payment flows and seasonal variations in demand for cash. The main function of open market operations is then to ensure that banks' demand for reserve balances is satisfied given autonomous factors affecting the supply of reserves such as shifts in government deposits between the central bank and banks, and the non-bank private sector's desire to switch between cash holdings and bank deposits. Failure to meet the demand for bank reserves would result in extreme interest rate volatility.

determine the completeness of sterilisation.[16] Although the authors do not make an explicit note nor calculate broad sterilisation coefficients, these two factors influence the relative impact of ΔNFA on broad money. Further, as Argy and Murray (1985, page 223) note: “there is surprisingly little, if any literature concerned with the effects of sterilisation *per se*, on financial variables”.

Meanwhile, estimation of Taylor-type monetary policy rules, while cognisant of the shift to interest rate-targeting (the interest rate as policy instrument) and which have as model set-up, the New Keynesian style approach, focus on whether central banks react to exchange rate changes or misalignments with the policy interest rate. However, as Engel (2009, page 22) states, “there is very little analysis of sterilized intervention in the new Keynesian framework”. In particular, most studies pertaining to emerging market economies seek to assess whether central banks have an additional objective in managing the exchange rate, beside inflation and output stabilisation. Mohanty and Klau (2004) for instance find a strong response of interest rates to persistent exchange rate shocks in Asian and Latin American economies over 1995-2002.

With these gaps in mind, in this chapter, we attempt to bring together the elements of interest rate-targeting, intervention and sterilisation using a simple theoretical model. We solve for the optimal monetary policy reaction function given the central bank’s objectives and the structural characteristics of the economy. We give attention to the effects of different sterilisation methods, crucially by (re)introducing a role for money into the model. We consider the existing arguments about the relevance of money and discuss how these may be pertinent in the context of analysing balance of payments flows, intervention and sterilisation. The resulting monetary policy reaction function shows how the policy interest rate behaves given various exogenous factors and how potential policy issues may arise with varying degrees of intervention and sterilisation.

[16] The authors state that liquidity in the banking system driven by large scale reserve accumulation can be partly neutralised by the sale of long-term Government bonds. If these bonds are then sold on to households and non-bank firms, it can be viewed as complete sterilisation.

3.2 THE MODEL

3.2.1 Central Bank Loss Minimisation Function

We assume that the representative central bank focuses on inflation and output stabilisation as its monetary policy objectives. The exchange rate is important for the achievement of these goals, and this is reflected in aggregate supply and aggregate demand. This, however, does not require that exchange rate stability be specified explicitly in the central bank's loss minimisation function[17]. As Cecchetti (2000, page 46) notes, "The decision to focus on the exchange rate path is the choice of an instrument, or intermediate target, not an objective. Under normal circumstances, policy-makers should not be concerned with the volatility of the exchange rate *per se*, but with the domestic inflation and growth outcomes produced by the path they choose for their instruments to follow". Similarly, while there may be several explanations for minimising interest rate volatility, Cecchetti (2000, page 50) states, "Optimal policy may entail interest rate smoothing, but there is no justification for this to be an explicit objective". Thus, from a monetary policy perspective, and to maintain the simplicity and generality of the model's exposition, the central bank's loss minimisation function is written as follows:

$$\text{Min } L_t = \frac{1}{2}\left[(\pi_t - \pi_t^T)^2 + \alpha(y_t)^2\right] \tag{3.1}$$

Where:

π_t = inflation rate

π_t^T = inflation target

y_t = domestic output gap; $\dfrac{\text{(actual real output less potential real output)}}{\text{potential real output}}$

α = parameter that reflects the weight that the central bank places on output stabilisation relative to inflation stabilisation

t = short- to medium-term horizon

[17] In reality, there are instances where countries have price stability and currency stability as separate monetary policy objectives. Based on legislation and extra-statutory elements, Ortiz (2009) finds that for 33 out of 45 central banks (across industrial and emerging market economies) price stability is usually the dominant monetary policy objective. In most cases it is a singular objective or is superior to other macroeconomic objectives specified in the law (general welfare, general economic health, growth and development). Nevertheless, the author highlights scenarios where there could be potential conflicts, in particular, seemingly equal ranked price and real economic objectives (for example, the US), and when the objective of currency stability is not equivalent to price stability (i.e. both are specified as objectives). The author also notes that in a 2006 sample of 36 central banks, 64% had a single quantifiable price stability objective, 11% had an exchange rate target, 6% had multiple targets, while 17% had no explicit target or a monitoring range.

The central bank seeks to minimise inflation and output growth deviations around a target inflation rate and potential output respectively. It minimises the loss function by manoeuvring the instruments at its disposal subject to several constraints that characterise the economy. It is assumed that the central bank operates primarily through a short-term interest rate. The following sections detail the structural equations for the economy and the derivation of the monetary policy reaction function.

3.2.2 Inflation

The inflation equation is defined as follows:

$$\pi_t = \beta_1 \pi_{t-1} + \beta_2 E_t \pi_{t+1} + (1 - \beta_1 - \beta_2)\left(\Delta e_t + \pi_t^f\right) + \beta_3 y_t + u_{\pi t} \tag{3.2}$$

$$(0 < \beta_1 < 1, 0 < \beta_2 < 1, \ \beta_1 + \beta_2 < 1, \ \beta_3 > 0)$$

where $E_t \pi_{t+1}$ = current expectation of inflation in the next period;
e_t = nominal effective exchange rate; π_t^f = foreign inflation;
$u_{\pi t}$ =cost-push shock

Equation (3.2) relates current inflation to lagged inflation, π_{t-1}, expected inflation, $E_t \pi_{t+1}$, the output gap, y_t, change in the nominal effective exchange rate, Δe_t, with an increase indicating depreciation (defined as a percentage change), foreign inflation, π_t^f, and cost-push shocks, $u_{\pi t}$.

The inclusion of both lagged inflation and expected future inflation is in line with the Fuhrer and Moore (1995) model of relative contracting that leads to inflation persistence. Fuhrer and Moore assume that agents negotiate real wages relative to the expected average of real contract wages over a two-period life (t, t+1). Contracts in effect in period t partly reflect past real wages. Fuhrer and Moore argue that the model provides a realistic reflection of the cost of disinflation policy and fits U.S. data.

The variables $\left(\Delta e_t + \pi_t^f\right)$ capture the influence of variations in import prices on inflation. Long-run homogeneity (long-run Phillips curve verticality) is imposed, that is, the right-hand side coefficients in the equation, with the exception of the coefficient on the output gap, sum to one.

3.2.3 Aggregate Demand

Aggregate demand is represented by the following output gap equation:

$$y_t = \gamma_1 y_{t-1} - \gamma_2(i_t - E_t\pi_{t+1} - r_t^*) + \gamma_3 z_t + u_{yt} \tag{3.3}$$

$(0 < \gamma_1 < 1;\ \gamma_2 > 0; \gamma_3 > 0)$

i_t = central bank policy interest rate, nominal
$E_t\pi_{t+1}$ = current expectation of inflation in the next period
r_t^* = natural real interest rate
$z_t = \dfrac{(q_t - q_t^*)}{q_t^*}$; q_t = current real effective exchange rate (increase reflects depreciation)
q_t^* = equilibrium real effective exchange rate
u_{yt}= aggregate demand shock

The output gap depends negatively on the difference between the real short-term interest rate and the natural real interest rate, $(i_t - E_t\pi_{t+1} - r_t^*)$; and positively on the lagged output gap, y_{t-1}, and the depreciation in the real effective exchange rate, relative to its equilibrium level, z_t.

3.2.4 Foreign Exchange Intervention and the Balance of Payments

We make the simplifying assumption that any accumulation of net foreign assets by the domestic economy is due solely to the central bank. Net inflows through the capital and financial accounts, ΔNK_t, reflect changes in the holdings of domestic assets by non-residents and do not encompass any transactions by domestic residents. Essentially, domestic residents do not invest abroad. The change in the central bank's net foreign assets $(\Delta NFA_{cb,t})$ is the sum of ΔNK_t and the current account surplus, CA_t.[18]

$$\Delta NFA_{cb,t} = CA_t + \Delta NK_t \tag{3.4}$$

18 Without central bank activity, CA and ΔNK balance out, without changes to domestic banking institutions' net foreign assets or liabilities.

The current account surplus is made up of the trade surplus and net investment income (receipts less expenditure) as in (3.5) below. For simplicity, compensation to employees and transfers are excluded. Given that the accumulation of net foreign assets is due solely to the central bank, $i_t^{f,iv} NFA_{cb,t-1}$ reflects inflows due to investment income earned by the central bank ($i_t^{f,iv}$ being the foreign interest rate on investments abroad)[19]. Net investment income should actually be net of interest paid on non-residents' holdings of domestic asset ($i_t^{d,iv} NK_{t-1}$, with $i_t^{d,iv}$ being the domestic interest rate on local investments) but for simplification purposes, we omit this term or consider it subsumed under ΔNK_t, without material consequences for the analysis.

$$CA_t = TB_t + i_t^{f,iv} NFA_{cb,t-1} \tag{3.5}$$

From (3.4) and (3.5):

$$\Delta NFA_{cb,t} = TB_t + i_t^{f,iv} NFA_{cb,t-1} + \Delta NK_t \tag{3.6}$$

$$\Delta NFA_{cb,t} - i_t^{f,iv} NFA_{cb,t-1} = TB_t + \Delta NK_t \tag{3.7}$$

Assuming that the central bank's foreign liabilities are zero, and foreign assets consist only of foreign exchange reserves ($FXR_{cb,t}$), such that $\Delta NFA_{cb,t} = \Delta FXR_{cb,t}$, this gives an expression for central bank foreign exchange intervention as follows:

$$\Delta FXR_{cbi,t} = TB_t + \Delta NK_t \tag{3.8}$$

Where $\Delta FXR_{cbi,t} = \Delta FXR_{cb,t} - i_t^{f,iv} FXR_{cb,t-1}$, represents central bank intervention

Based on (3.8) above, central bank intervention is driven by the trade surplus and capital inflows. The real trade surplus as a ratio to lagged real output (Y_{t-1}) in (3.9) below is determined by an exogenous component and increases as the real

19 The same interest rate is assumed to apply to both, foreign assets and foreign liabilities.

effective exchange rate depreciates relative to the equilibrium exchange rate level[20]. In (3.10), net real capital inflows as a ratio to Y_{t-1} depends on an exogenous component[21], which is not influenced by short-term speculation; and imperfectly on the variables that constitute the uncovered interest rate parity condition. In the equation, c represents the degree of international asset substitutability[22]. If $c \rightarrow \infty$, domestic and foreign assets are perfect substitutes and capital is perfectly mobile. If $c \rightarrow 0$, deviations from the uncovered interest parity would not lead to infinite capital flows. Here it is assumed that $0 < c < \infty$[23].

$$\frac{TB_{R,t}}{Y_{t-1}} = \bar{t} + \theta z_t \tag{3.9}$$

$$\frac{\Delta NK_{R,t}}{Y_{t-1}} = \bar{k} + c\left[E_t \Delta e_{t+1} + (i_t - i_t^f)\right] \tag{3.10}$$

$\bar{t}$ = exogenous real trade surplus
z_t = real effective exchange rate (increase reflects depreciation)
$\bar{k}$ = exogenous real net capital inflows
e_t = current nominal exchange rate (increase reflects depreciation)
$E_t e_{t+1}$ = current expectation of the exchange rate at time t+1
$E_t \Delta e_{t+1} = \dfrac{(e_t - E_t e_{t+1})}{e_t}$
i_t^f = foreign interest rate

It is generally accepted that a random walk forecast of the exchange rate tends to outperform other models in out-of-sample forecasting, and thus one can assume that $E_t e_{t+1} = e_t$. Incorporating this assumption into (3.10) would eliminate the term $E_t \Delta e_{t+1}$. Nevertheless, empirical evidence on the random walk hypothesis, where emerging markets are concerned, is mixed (see for instance Azad (2009)). Results are sensitive to the methodology employed, the sample period and the data series. Rejection of the random walk hypothesis, however, is not inconsistent with active foreign exchange intervention. As such, an alternative assumption is to have the expected nominal exchange rate change as a function of the extent of perceived real exchange rate misalignment[24]. That is, $E_t \Delta e_{t+1} = \varphi z_t$. The expectation of a nominal

[20] The Marshall-Lerner condition is assumed to hold without inertia.

[21] Expressing the trade balance and net capital inflows as ratios to output ensures stationarity. The use of lagged output as the denominator is consistent with assuming that the exogenous determinants on the right-hand-side of the equations primarily reflect the effects of lagged relative incomes (foreign and domestic).

[22] The parameter c captures capital account restrictions and risk characteristics.

[23] The discussion on international asset substitutability draws on Brissimis *et al.* (2002).

[24] We assume perceived = actual for ease of exposition, but clearly this need not be the case, and the difference would influence the complexity of the resulting monetary policy reaction function.

exchange rate appreciation in the next period is a function of the perceived real exchange rate undervaluation in the current period. Using this assumption, (3.10) can be written as:

$$\frac{\Delta NK_{R,t}}{Y_{t-1}} = \bar{k} + c\left[\varphi z_t + (i_t - i_t^f)\right] \tag{3.11}$$

Expressing the elements of (3.8) in real terms by deflating through with a common price index, then taking ratios to Y_{t-1}, and substituting (3.9) and (3.11) result in the following:

$$\frac{1}{Y_{t-1}}\left(\Delta FXR_{Rcbi,t}\right) = \frac{1}{Y_{t-1}}\left(TB_{R,t} + \Delta NK_{R,t}\right) \tag{3.12}$$

$$\frac{\Delta FXR_{Rcbi,t}}{Y_{t-1}} = \bar{t} + \theta z_t + \bar{k} + c\left[\varphi z_t + (i_t - i_t^f)\right] \tag{3.13}$$

Rearranging (3.13) gives:

$$\frac{\Delta FXR_{Rcbi,t}}{Y_{t-1}} = \bar{t} + \bar{k} + (\theta + c\varphi)z_t + c\left(i_t - i_t^f\right) \tag{3.14}$$

In (3.14), the amount of real central bank intervention, as a ratio to Y_{t-1}, is determined by exogenous trade and capital flows, the real exchange rate disequilibrium which matters for exchange rate sensitive trade flows (as reflected by the coefficient θ) and capital flows (as reflected by the coefficient φ), the interest rate differential which influences capital flows, and the degree of international asset substitutability, c. The higher is c, the higher are capital inflows and consequent intervention if z_t and/or $\left(i_t - i_t^f\right)$ are larger than zero.

3.2.5 The Role of Money

This section deals with the question as to whether there should be a role for money in the model, particularly when sterilised intervention is a policy option for central banks. As evident in Sections 3.2.2 and 3.2.3 above, money does not figure explicitly as a variable in the inflation and output gap equations that tend to typify current models of monetary policy. There has been a general decline in the importance placed by policymakers on money, with the shift away from monetary targeting, either with base money as the policy instrument and/or a monetary aggregate as the intermediate target. As a result, money is endogenous, with whatever changes to demand being accommodated whilst the policy interest rate remains unchanged. Existing literature dealing with sterilised intervention, meanwhile, have tended to assume a direct relationship between money and inflation. As mentioned in the literature review, the models in these studies, however, do not adequately reflect the current state of policy-making[25]. In this section, we attempt to provide some reconciliation between these two opposing frameworks.

Whilst the long-run correlation between money and inflation is an accepted empirical phenomenon, the short-to medium-term effects of money on output and inflation are much less clear and the subject of considerable debate. Rudebusch and Svensson (2002, page 422) write, "As a general characterization, central bankers typically hold the view that movements in the monetary aggregates play no role in the direct quarter-by-quarter determination of either output or prices; however a sizeable fraction also concedes that money may have some value as an indicator of economic developments". Woodford (2008), while arguing that there is no need to assign money a particularly prominent role à la the European Central Bank (ECB)'s "monetary analysis" pillar, nevertheless concedes that there is no a priori reason to exclude monetary variables from the set of indicators that are taken into account in a central bank's information set. There exists, however, pockets of research in support of money containing unique information beyond that which are obtained from other economic indicators.

King (2002), and Bridges and Thomas (2012)[26] provide useful overviews of the literature on the plausible role for money in the monetary transmission mechanism. King, for example, acknowledges the limitations inherent in old and new macroeconomic models which do not account for a multitude of real and financial assets which are imperfect substitutes. He highlights the portfolio rebalancing effect, the real balance effect, and the liquidity service effect of money.

The portfolio rebalancing effect is the adjustment of the prices and yields on other assets concomitant with changes in money. For a given level of the short-term real interest rate, Meltzer (1999) finds that real base money growth matters for

[25] The studies present models where a monetary aggregate is still the operating or intermediate target of monetary policy. For instance, Brissimis *et al.* (2002) posit the following money-inflation relationship: $\Delta p_t = \mu_1(\Delta NFA_t + \Delta NDA_t) + \mu_2 \Delta p_{t-1}$, with ΔNDA_t as the monetary policy instrument.

[26] Bridges and Thomas (2012) is an example of recent research reflecting the renewed interest in the role of money in providing a framework for the analysis of the effects of quantitative easing in the wake of the global financial crisis.

consumption growth in the US. Nelson (2000) reaffirms this in the case of economic growth for the US and the UK. The theoretical postulation for the results is that there are many real interest rates and asset prices that are relevant for economic activity and the real short-term interest rate is not adequately representative of these yields. Instead, real money balances act as a proxy for changes in relative yields and real wealth which supplement the effect of a change in a specific short-term interest rate[27]. Meltzer (1995), in a three-asset model (with interest rate on securities and asset prices determined by equilibrium in the base money and bond markets), illustrates the interplay of relative prices. A change to base money and at the same time a change to the stock of securities have similar effects on the interest rate for securities but different effects on the asset price level – an open market operations purchase of securities lowers the interest rate and raises the asset price on a net basis. In an interest rate-targeting framework, the money supply adjusts to meet money demand, as the interest rate is kept steady. However, in equilibrium asset prices also change, which affects spending and output. Thus, "Control of the interest rate does not avoid portfolio or output market responses and may amplify these responses" (page 56), when the money and asset markets are interrelated.

As an example of the portfolio rebalancing effect, King (2002, page 170) describes the satiation point in the context of monetary policy at zero interest rates: "...if the demand for money is satiated at a finite level as interest rates tend to zero, then the creation of money beyond that point would be translated into a demand for other assets and higher incomes. ...changes in household portfolios lead to changes in relative yields on different financial and real assets, and hence on asset prices and, in turn, real spending. Despite interest rates remaining at zero, monetary policy, in this world, can influence nominal spending and incomes".

27 Meltzer (1999) uses two stage least squares and carries out regressions with base money and M1 respectively, with consistent results of coefficient significance. The sample period covered is 1950q4-1995q4. Nelson (2000) uses lagged real base money and carries out regressions for the sample period 1961q1-1999q2, with sub-sample regressions for robustness. Nelson notes that standard optimising models provide little rationale for the findings of statistical significance of real money balances. He develops a general equilibrium framework with a forward-looking partial adjustment equation for real money balances such that long-term real interest rates enter the equation. He finds that real money balances are more negatively correlated with long-term rates than with short-term rates. He suggests that for his model, "conditioning on the real long rate would be sufficient to remove the incremental information contained in money growth about economic activity. But it is conceivable that in more general cases, where many yields enter both the aggregate demand and money demand functions, the information in money about aggregate demand would be beyond that contained in securities market interest rates, both short-term and long-term,"(page 25). The model does not allow for exogenous money supply shocks but if an exogenous money supply rule is implemented, this magnifies the impact of money on real interest rates and aggregate demand.

King (2002, page 171) further notes "most finance theory is based on the assumption that equilibrium yields on assets, including risk premia, are independent of the quantities of the supplies of different assets. Hence the search for a better model of the monetary transmission mechanism is, in part, a search for evidence of supply effects on financial asset yields. That is why the view that money matters, over and above interest rates, is intimately bound up with a question of whether the supplies of different assets affect yields, and hence whether the composition of government debt affects both money and real economic behaviour".

The real balance effect, associated with Pigou (1943) and Patinkin (1965), suggests that a monetary expansion raises net real money holdings, which represents an increase in net wealth, and in turn stimulates aggregate demand. King (2002) objects to the significance of this effect based on the notion that only an increase in "outside" money (base money) constitutes an increase in net wealth. "Inside" money (broad money) on the other hand has a mirror debt commitment. We suggest however, that this may not necessarily be true in an open economy since domestic assets need not equal domestic liabilities at the aggregate level for the non-bank private sector.

King (2002) highlights the role of money in providing a liquidity service which reduces financial frictions in the form of transaction costs (building on Sidrauski (1967)), as well as borrowing constraints. Ireland (2004) presents money and consumption as non-separable in the utility function, with the result that real money balances adjusted for shifts in money demand shocks appear in both the forward-looking IS curve and the forward-looking Phillips curve. Empirical estimations for the US over 1980q1-2001q3 using M1 and M2, however, fail to provide evidence that real money balances enter either equation. Goodfriend (2000, 2005) and Chadha *et al*. (2008) investigate the relationship between broad money and the external finance premium via micro-founded theoretical modelling. Goodfriend discusses the broad liquidity services yield which is derived from the reduced exposure to the external finance premium with increased holdings of broad liquidity assets. An increase in broad liquidity assets reduces this yield and leads to portfolio rebalancing. This results in higher asset prices and net worth, which bring credit spreads down. Chadha *et al.* endogenise the supply of money via bank loans and show that money and financial spreads become negatively correlated when loan supply shocks in the form of loan monitoring and collateral dominate money demand or goods sector productivity shocks.

Aside from the above, there is also literature relating money to steady-state inflation, and advocating the usefulness of money as a cross-checking mechanism in the presence of measurement error. Gerlach (2003, 2004) provides an empirical interpretation of the ECB's two-pillar monetary policy strategy, with a non-structural augmentation to the standard Phillips curve. The monetary analysis pillar captured by trend monetary growth accounts for changes in steady-state inflation by influencing inflation expectations while the economic analysis pillar captured by the output gap accounts for short-run movements in inflation around the steady-state rate. Gerlach's empirical work suggests that M3 growth contains information about future inflation in the Euro Area that is not already embedded in the current inflation rate. Gerlach nevertheless views the results as neither suggesting M3 as the best indicator of inflation nor that a separate pillar for monetary growth is required.

Nelson (2008), in a critique of Woodford (2008), also alludes to the long-run importance of money for the determination of steady-state inflation in New Keynesian models. Nelson's critique is not in terms of model adequacy but rather concerns the lack of explanation with regard to how steady-state inflation or the inflation target is determined if, in the long run, the central bank has no control over the short-term interest rate and cannot affect real interest rates. The short run/long run distinction has important implications for the central bank to affect interest rates. Open market operations affect nominal and real interest rates only with nominal price rigidity. In the long run, prices move by the same percentage as the nominal money stock. As such, an understanding of how a central bank's actions determine long-run inflation expectations when the real interest rate cannot be controlled is needed, and this is where steady-state money growth matters. The central bank's open market operations continue in the long run to affect nominal money growth. Thus, the steady-state money growth, delivered by a specified quantity of open market operations, provides a guide for hitting the desired inflation rate.

Beck and Wieland (2008) highlight that while potential output cannot be assessed with any certainty, research with Keynesian-style models has nevertheless emphasised the importance of the output gap. They develop a justification for including money in the policy reaction (interest rate) rule by allowing for imperfect knowledge regarding unobservable variables such as potential output and the equilibrium interest rate. Through simulations based on US and Germany in the 1970s, the authors show that the misperceptions about potential output, which cause a bias in policy setting, make the long-run relationship between money growth and inflation quite apparent, based on filtered measures of inflation and money growth. Essentially, the increase in average money growth and inflation is due to the same source - persistent central bank misperceptions about potential output. "Cross-checking" and changing the interest rate in response to sustained shifts in filtered money growth helps the central bank overcome the bias.

From the literature presented in this section, it is clear that there is an active debate on the role of money. We acknowledge that we have only provided an overview and that there are clearly more technical details and issues pertaining to the empirical evidence and the link to rigorous general equilibrium theoretical foundations. Bridges and Thomas (2012) note that there is not yet a generally accepted way of integrating money, especially broad money, into current DSGE models. We rely on a simple approach particularly since we attempt to integrate three elements – interest rate-targeting, the role of money, and intervention and sterilisation. For our purposes, the literature provides sufficient support for the inclusion of money in our simple model, particularly in connection to the aggregate demand equation, and the role of money as a proxy for monetary conditions not summarised by the short-term interest rate. The issues of imperfect substitutability among a range of financial and real assets; the demand for and supply of assets, including money; and portfolio rebalancing are all relevant to emerging market economies. These economies experience large external inflows which affect the supply of and demand for money, and tend to carry out sterilisation, both of which affect the demand for and supply of other assets and hence their yields. Consequently we augment equation (3.3), with a term representing real broad money growth as follows[28]:

[28] A question that arises is whether both r_t^* (consistent with a closed output gap over the medium-term) and $\Delta bm_{R,t}$ need to appear in the output gap equation. Given the difficulties in measuring r_t^* and since $\Delta bm_{R,t}$ is in a way, an indicator of r_t^*, there is a case for dropping r_t^*, though this is best addressed in a micro-founded model (see for example, Berger and Weber (2012)). For our purposes, we retain r_t^*, and to an extent, see having both as a cross-checking device.

$$y_t = \gamma_1 y_{t-1} - \gamma_2(i_t - E_t\pi_{t+1} - r_t^*) + \gamma_3 z_t + \gamma_4 \Delta bm_{R,t} + u_{yt}$$

$$\Delta bm_{R,t} = \text{percentage change in real broad money} \tag{3.15}$$

Conceptually, in terms of the money determinants identity, the change in the supply of broad money is made up of changes in net foreign assets and changes in net domestic assets, the main driver of which is credit growth. A simplification seen in Section 3.2.4 was that any accumulation of net foreign assets is solely due to the central bank. We take this simplification further in the following sections, by assuming that the central bank's foreign exchange intervention is the only factor driving broad money growth. Essentially, we exclude the credit growth portion.

The mechanics of the impact of foreign exchange intervention via $\Delta bm_{R,t}$ is explored in detail using a portfolio balance model in subsection 3.2.6.2 (a). For now, we highlight that the underlying assumption is that $\Delta bm_{R,t}$ functions mainly as a proxy for the possible wedge that may arise between the policy interest rate and market interest rates due to portfolio rebalancing, and also captures some real balance effects via changes in net wealth. To illustrate the former point, we consider that there is some composite market interest rate, i_t^m, taking into account various yields on financial assets, which is the actual interest rate that affects aggregate demand. Then, broad money demand and supply deviations from trend ($bm_{g,t}^d$ and $bm_{g,t}^s$ respectively) are specified as functions of the output gap (y_t), i_t^m and shocks, as follows[29]:

$$bm_{g,t}^d = y_t - \delta i_t^m + u_{md,t} \tag{3.16}$$

$$bm_{g,t}^s = y_t + \omega i_t^m + u_{ms,t} \tag{3.17}$$

Equalising money demand and money supply, and solving for i_t^m:

$$i_t^m = \frac{1}{\omega+\delta}\left(u_{md,t} - u_{ms,t}\right) \tag{3.18}$$

Equation (3.18) indicates that i_t^m is affected by positive money demand and money supply shocks in opposite directions, with the latter having dampening effects. As

[29] Our simple illustration with these functions is done solely to provide an intuitive expression of the link between money demand and supply shocks with market interest rates. The functions are separate from the model presented in this chapter.

such, a positive money supply shock not offset by a demand shock, or a negative money demand shock without a countervailing supply shock reduces i_t^m so that equilibrium is restored; this whilst the policy interest rate remains unchanged. There are asymmetrical responses in i_t^m depending on the nature of shocks to broad money even as the central bank accommodates all shocks to base money demand to keep the policy interest rate stable in an interest rate-targeting framework.

3.2.6 Monetary Policy Reaction Function

We have thus far framed the discussion in the context of a monetary policy framework with an interest rate as the main policy instrument. Ho (2008) provides support for such an assumption for this model of a stylised emerging market economy, though there are a few exceptions among the countries that enter the MSCI index for emerging market economies. The author finds, in a study of monetary operating frameworks in 17 countries as of March 2007, that most central banks express their official monetary policy stance in terms of an interest rate, for example, a central bank facility/operation rate, or a target for a market rate. At the same time, the day-to-day operating objective of central banks has focused more on stabilising some measure(s) of short-term interest rate, less on targeting quantities (such as reserve money). In terms of the nature of instruments, there has been reduced use of direct controls, and more use of indirect instruments based on market mechanisms and incentives.

The monetary policy reaction function is derived by minimising (3.1) with respect to the policy instrument, i_t, subject to the constraints described in Sections 3.2.2 to 3.2.5.

We explore three cases. First we leave money as exogenous and derive the monetary policy reaction function, as the baseline case. Then we consider the cases of the monetary policy reaction function with intervention, in scenarios of complete and incomplete sterilisation.

3.2.6.1 *Monetary policy reaction function with exogenous money*

As expected inflation in the next period, $E_t\pi_{t+1}$, is endogenous, we assume that it depends on the current inflation target and lagged inflation. The relative weight on the former (λ) can be viewed as reflecting the credibility of the central bank.

$$E_t\pi_{t+1} = \lambda\pi_t^T + (1-\lambda)\pi_{t-1} \tag{3.19}$$

We incorporate (3.19) into the augmented output gap equation (3.15) to obtain (3.20). A reduced-form of the inflation equation (3.2) is also derived, by substituting (3.15) and (3.19) into (3.2). This gives us equation (3.21).

$$\begin{aligned} y_t = {} & \gamma_1 y_{t-1} - \gamma_2 i_t + \gamma_2\left(\lambda\pi_t^T + (1-\lambda)\pi_{t-1} + r_t^*\right) \\ & + \gamma_3 z_t + \gamma_4 \Delta bm_{R,t} + u_{yt} \end{aligned} \tag{3.20}$$

$$\begin{aligned} \pi_t = {} & [\beta_1 + \beta_2(1-\lambda) + \beta_3\gamma_2(1-\lambda)]\pi_{t-1} + (\beta_2 + \beta_3\gamma_2)\lambda\pi_t^T \\ & + (1-\beta_1-\beta_2)\left(\Delta e_t + \pi_t^f\right) + \beta_3\gamma_1 y_{t-1} - \beta_3\gamma_2 i_t + \beta_3\gamma_2 r_t^* \\ & + \beta_3\gamma_3 z_t + \beta_3\gamma_4\Delta bm_{R,t} + \beta_3 u_{yt} + u_{\pi t} \end{aligned} \tag{3.21}$$

Then, the reduced-form inflation equation and the output gap equation are substituted into the loss function:

$$L_t = \frac{1}{2}\left[(\pi_t - \pi_t^T)^2 + \alpha(y_t)^2\right]$$

$$= \frac{1}{2}\Big[\big\{[\beta_1 + \beta_2(1-\lambda) + \beta_3\gamma_2(1-\lambda)]\pi_{t-1} + (\beta_2 + \beta_3\gamma_2)\lambda\pi_t^T + (1-\beta_1-\beta_2)\big(\Delta e_t + \pi_t^f\big) + \beta_3\gamma_1 y_{t-1} - \beta_3\gamma_2 i_t + \beta_3\gamma_2 r_t^* + \beta_3\gamma_3 z_t + \beta_3\gamma_4\Delta bm_{R,t} + \beta_3 u_{yt} + u_{\pi t} - \pi_t^T\big\}^2 + \alpha(\gamma_1 y_{t-1} - \gamma_2 i_t + \gamma_2\big(\lambda\pi_t^T + (1-\lambda)\pi_{t-1} + r_t^*\big) + \gamma_3 z_t + \gamma_4\Delta bm_{R,t} + u_{yt})^2\Big]$$

(3.22)

The loss function is minimised with respect to i_t:

$$\frac{\partial L}{\partial i_t} = 0$$

$$\Big[[\beta_1 + \beta_2(1-\lambda) + \beta_3\gamma_2(1-\lambda)]\pi_{t-1} + (\beta_2\lambda + \beta_3\gamma_2\lambda - 1)\pi_t^T + (1-\beta_1-\beta_2)\big(\Delta e_t + \pi_t^f\big) + \beta_3\gamma_1 y_{t-1} - \beta_3\gamma_2 i_t + \beta_3\gamma_2 r_t^* + \beta_3\gamma_3 z_t + \beta_3\gamma_4\Delta bm_{R,t} + \beta_3 u_{yt} + u_{\pi t}\Big](-\beta_3\gamma_2) + \alpha\big[\gamma_1 y_{t-1} - \gamma_2 i_t + \gamma_2\big(\lambda\pi_t^T + (1-\lambda)\pi_{t-1} + r_t^*\big) + \gamma_3 z_t + \gamma_4\Delta bm_{R,t} + u_{yt}\big](-\gamma_2) = 0$$

(3.23)

Solving for i_t:

$$i_t = \left[\frac{\beta_3\big(\beta_1 + \beta_2(1-\lambda)\big)}{\gamma_2({\beta_3}^2 + \alpha)} + (1-\lambda)\right]\pi_{t-1} + \left[\frac{\beta_3(\beta_2\lambda - 1)}{\gamma_2({\beta_3}^2 + \alpha)} + \lambda\right]\pi_t^T + \frac{\beta_3}{\gamma_2({\beta_3}^2 + \alpha)}\left[(1-\beta_1-\beta_2)\big(\Delta e_t + \pi_t^f\big) + u_{\pi t}\right] + \frac{\gamma_1}{\gamma_2}y_{t-1} + r_t^* + \frac{\gamma_3}{\gamma_2}z_t + \frac{\gamma_4}{\gamma_2}\Delta bm_{R,t} + \frac{1}{\gamma_2}u_{yt}$$

(3.24)

Equation (3.24) is the solution for the optimal interest rate policy in terms of various exogenous factors that determine inflation and the output gap[30]. By

30 The second derivative of the loss function with respect to i_t is $\frac{\partial^2 L}{\partial i_t^2} = (\beta_3^2 + \alpha)\gamma_2^2$. Since $\frac{\partial^2 L}{\partial i_t^2} > 0$, this confirms that we have solved for a minimisation problem.

assumption, with no intervention, $\Delta bm_{R,t}$=0 in (3.24). This is effectively a floating exchange rate regime. The exchange rate nevertheless still matters for interest rate policy decisions as the nominal exchange rate affects inflation directly through Δe_t, (an increase (depreciation) leading to a rise in inflation, and triggering an increase in the policy rate) and the real effective exchange rate affects the output gap. A positive deviation of the real effective exchange rate from equilibrium, $z_t > 0$, signals undervaluation and widens the output gap leading to a rise in the policy interest rate.

Higher lagged inflation, π_{t-1}, a rise in foreign inflation, π_t^f, and cost-push shocks, $u_{\pi t}$, directly lead to higher inflation and a higher policy interest rate. Meanwhile, a lower inflation target π_t^T requires a higher policy rate (if $\frac{\beta_3}{\gamma_2({\beta_3}^2+\alpha)} > \frac{\lambda}{1-\beta_2\lambda}$, since we know $(\beta_2\lambda - 1) < 0)$. However, the higher is λ (the credibility of the inflation target) and β_3 (the impact of the output gap on inflation), the smaller is the movement needed in the policy interest rate as agents will recognise that a lower inflation target and a concomitant rise in the policy rate will depress aggregate demand and inflation. A higher λ also reduces the extent of persistence emanating from π_{t-1} and the cost of disinflation policy.

An increase in the lagged output gap, $y_{t-1,}$, a rise in the natural real interest rate, r_t^* (which signals a wider gap against the actual real short-term interest rate and hence an easing of policy), and aggregate demand shocks, u_{yt} lead to a higher output gap, y_t which requires a higher policy interest rate.

As set forth in (3.1), the parameter α reflects the weight the central bank places on output stabilisation relative to inflation stabilisation. From (3.24), it can be observed that as this parameter increases in size, the smaller are the coefficients on the factors affecting inflation directly. The coefficient on $u_{\pi t}$ is $\frac{\beta_3}{({\beta_3}^2+\alpha)}$ times the size of the coefficient on u_{yt}. The policy rate response to $u_{\pi t}$ is smaller than the response to u_{yt} if $\alpha > \beta_3(1-\beta_3)$.

Finally, in a floating exchange rate regime, it appears that the interest rate policy decision is independent of the foreign interest rate, given the specification of the inflation and output gap equations, and the assumption that $\Delta bm_{R,t} = 0$. With this assumption, there is no sustained nominal exchange rate depreciation or appreciation – trade flows and net capital flows tend to offset one another.

3.2.6.2 Monetary policy reaction function with intervention and sterilisation

In this section, we consider how the optimal monetary policy reaction function would look like when there is intervention, with complete sterilisation as well as with less than complete sterilisation. In order to do this, we first clarify how intervention and sterilisation affect broad money and define complete sterilisation. Our approach is to use a portfolio balance model of the financial sector, drawing on Argy and Murray (1985), and this is discussed in the following subsection.

(a) Money, portfolio balance and sterilisation

The goal of sterilisation is to insulate domestic liquidity from foreign exchange intervention and maintain monetary policy independence. Under a flexible exchange rate regime, large current account and capital account inflows result in exchange rate appreciation which offsets some of the imbalances and inflationary risk associated with an increased money stock, and leads to adjustments in inflows. In a fixed or closely managed exchange rate regime, the build-up in domestic liquidity and inflation pressures have to be managed in other ways, including through effective sterilisation.

With a short-term interest rate as the operating target, changes in base money (ΔRM) and the central bank's net domestic assets (ΔNDA), which encompasses its monetary operations,[31] become endogenous with the amount supplied depending on the demand for these balances given the central bank's mandate to maintain a specific interest rate level consistent with inflation and output stabilisation. The central bank conducts its monetary operations, injecting or withdrawing liquidity, depending on the factors affecting liquidity including foreign exchange intervention. Since any amount of money is supplied to meet demand, incomplete base money sterilisation is possible even if it does not reflect an inability to "control" liquidity.

[31] By monetary operations, we mean market based mechanisms, namely open market operations through repos/reverse repos and outright sales and purchases of securities, as well as the issuance of central bank securities.

Disyatat (2008, page 17) states: "the liquidity impact of foreign exchange intervention in the money market is much the same as any other autonomous factor affecting liquidity and thus must be offset by the central bank to hold interest rates steady". We would refine this statement by clarifying that the extent to which any of the factors affecting liquidity are offset, regardless of their source, depend on the private sector's demand to hold money balances.

Base money sterilisation, does not, however, imply broad money sterilisation. Monetary operations have varying effects on broad money depending on the sector from which liquidity is absorbed, whether non-bank private agents or banks. Crucially, as suggested in Section 3.2.5, depending on how broad money evolves, yields on financial assets which signal monetary conditions are affected even if the short-term policy interest rate is unchanged. This can be illustrated with a simple asset portfolio model of the financial sector in the domestic economy. In the model that follows, we examine the effects of sterilisation of broad money under scenarios of different portfolio preferences when there are trade and portfolio capital inflows respectively.

There are three financial assets available to the domestic non-bank private sector: money, bonds and equity[32]. The sum of these three assets is assumed to comprise total gross financial wealth. For consistency with the discussion in Section 3.2.4, it is assumed that no foreign assets are held by the domestic non-bank private sector[33]:

$$\frac{BM}{W} = -b_1 i^b - d_1 i^e + f_1 W \tag{3.25}$$

$$\frac{E^R}{W} = -b_2 i^b + d_2 i^e + f_2 W \tag{3.26}$$

$$\frac{B^R}{W} = b_3 i^b - d_3 i^e + f_3 W \tag{3.27}$$

[32] It is assumed that Ricardian equivalence does not hold, and holdings of Government bonds are considered as wealth, without implied future tax liabilities. Intergenerational transfers as described by Barro (1974) are not in operation.

[33] Argy and Murray (1985) consider three-asset (without equity) and four-asset (with equity) models respectively, and include foreign assets as one of the wealth components. There is no explicit distinction between sectors. We base our model on Argy and Murray's four-asset model set-up to describe the gross financial wealth of the non-bank private sector but exclude foreign assets. Additionally, we introduce simple supply-demand and balance sheet constraints to explicitly illustrate the interplay between the non-bank private sector, the central bank, banks and non-residents.

$$W = M + E^R + B^R \tag{3.28}$$

W = gross financial wealth of the domestic non-bank private sector
BM = domestic broad money (currency in circulation and deposits of the non-bank private sector)
E^R = domestic equity held by the domestic non-bank private sector
B^R = domestic bonds held by the domestic non-bank private sector
i^b = return on domestic bonds, current yield = interest rate/market price
i^e= return on domestic equity, market capitalisation rate = (dividend paid +capital gain)/market price

A rise in i^b leads to a reduction in the combined share of wealth held as broad money and equity ($b_3 = b_1 + b_2$). Similarly, a rise in i^e leads to a reduction in the combined share of wealth held as broad money and bonds ($d_2 = d_1 + d_3$). We assume that broad money's own rate of return is zero as a simplification. A rise in wealth, through a trade surplus, may change the proportion of wealth held in each type of asset ($f_1 + f_2 + f_3 = 0$). Portfolio capital inflows cause a shift out of equity and bonds into money, as non-residents' demand for existing equity and bonds reduces their returns. There is no effect on total wealth (capital gains are not built into the wealth constraint).

Equity within the domestic economy (E^{TD}) is held by the domestic non-bank private sector (E^R) and non-residents (E^{NR}):

$$E^{TD} = E^R + E^{NR} \tag{3.29}$$

Total domestic bonds, (B^{TD}) are held by the domestic non-bank private sector (B^R), domestic banking institutions (B^{BS}) and non-residents (B^{NR}):

$$B^{TD} = B^R + B^{BS} + B^{NR} \tag{3.30}$$

The supply of bonds consists of bonds issued by the Government (BG), the central bank (BCB), and the non-bank private sector (BR):

$$B^{TD} = BG + BCB + BR \tag{3.31}$$

The central bank's balance sheet constraint is as follows[34]:

$$\mathrm{FXR_{cb}} - \underbrace{\mathrm{D^G} - \mathrm{BCB} - \mathrm{D^{BS}}}_{\mathrm{NDA}} = \mathrm{RM} \tag{3.32}$$

RM = base money (currency in circulation (CIC) + required reserves (RR) + excess reserves (RR))
$\mathrm{FXR_{cb}}$ = foreign exchange reserves
$\mathrm{D^G}$ = Government deposits
BCB = stock of outstanding central bank securities
$\mathrm{D^{BS}}$ = Net borrowing from the banking system through repos, outright sales of securities (non-central bank securities) and deposit facilities ($\mathrm{C^{BS}}$)

The banking system's balance sheet constraint is as follows:

$$\mathrm{L^{BS}} + \mathrm{B^{BS}} + (\mathrm{RR} + \mathrm{ER}) + \mathrm{C^{BS}} = \mathrm{D^R} \tag{3.33}$$

$\mathrm{L^{BS}}$ = loans by the banking system to the domestic non-bank private sector
$\mathrm{B^{BS}}$ = holdings of securities, includes all liquidity operations with the central bank which involve securities
$\mathrm{C^{BS}}$ = deposits with the central bank
$\mathrm{D^R}$ = deposits of the non-bank private sector, equivalent to BM less currency in circulation

To illustrate the effect of intervention and sterilisation, we assume that the central bank intervenes in the full amount of current account and capital account inflows. Complete sterilisation would entail completely offsetting the impact of foreign exchange intervention/balance of payments flows on broad money. Regardless, the central bank conducts its liquidity operations with the banking system to keep the policy interest rate stable.

We consider as the first case, a rise in financial wealth due to a trade surplus $(\bar{\mathrm{t}} > 0)$. If the domestic non-bank private sector chooses to hold the full amount of this rise in wealth as money $(\mathrm{f_1} > 0, \mathrm{f_2} < 0 \text{ and } \mathrm{f_3} < 0)$, then their portfolio adjustment would not lead to changes in bond and equity returns, as demand for and supply of these assets are unchanged while the demand for money is fully accommodated $(\frac{\mathrm{BM}}{\mathrm{W}} \uparrow, \frac{\mathrm{E^R}}{\mathrm{W}} \downarrow, \frac{\mathrm{B^R}}{\mathrm{W}} \downarrow)$. If the central bank attempts to directly sterilise any

[34] We assume the central bank is in a net debtor position with the banking system, that is, the starting position is one of surplus liquidity.

amount of the increase in broad money, thus changing the initial proportions of asset holdings by the non-bank private sector, the return on domestic bonds must rise in order to induce residents to switch from money to bond holdings (the central bank issues bonds: $\mathrm{BCB} \uparrow$). The increase in bond returns will, in turn, lead to an increase in equity returns as demand for equity is reduced given the shifts in relative returns for bonds and equity. This effect is partly mitigated by attempts to shift out of money into equity. If the central bank wants to avoid an increase in bond and equity returns arising from its operations, then it would allow broad money to increase, and will not sterilise the new funds of the non-bank private sector.

It is important to note however, that under an interest rate-targeting framework, the central bank would still absorb the resulting net domestic liquidity increase in the banking system arising from its intervention operations to the extent that is required to keep the short-term interest rate target stable ($\mathrm{FXR_{cb}} \uparrow$ offset by $\mathrm{BCB} \uparrow / \mathrm{D^{BS}} \uparrow$)[35]. Note that the banking system has higher deposits, $\mathrm{D^R}$ arising from the trade surplus – this represents excess liquidity which needs to be invested. Thus, the liquidity operations by the central bank with the banking system are unlikely to drive up bond returns. The increase in deposits, however, may have an impact on monetary conditions. It could constitute a loan supply shock which drives down lending rates and leads to credit growth.

In the second case, if the domestic non-bank private sector chooses to hold the financial wealth arising from the trade surplus in equal proportions in all three assets – money, bonds and equity ($\mathrm{f_1 = f_2 = f_3 = 0}$), there would be downward pressure on bond and equity returns, assuming supplies of these assets are unchanged. In addition to the proportion of new wealth held as money, broad money still increases to the extent that bonds and equity are purchased from other domestic non-bank residents, as opposed to banks and non-residents. In this scenario, the central bank, by partially sterilising the increase in broad money, can avoid the downward pressure on bond returns by supplying bonds to the non-bank private sector. As bond returns remain steady, downward pressures on equity returns are

[35] Monetary operations keep base money relatively stable. Since broad money is a multiple of base money through the reserve-deposit and currency deposit ratios, what is observed is a fluctuation in the multiplier. Broad money, BM = $[(1 + \mathrm{cr})/(\mathrm{rrr} + \mathrm{err} + \mathrm{cr})]$RM, where cr = currency-deposit ratio, rrr = required reserves ratio, err = excess reserves ratio. The multiplier, m = $(1 + \mathrm{cr})/(\mathrm{rrr} + \mathrm{err} + \mathrm{cr})$. If we assume that the trade surplus is held as deposits, there is little change to RM, while cr falls, and m and BM increase.

somewhat alleviated as demand for equity is reduced given shifts in relative returns. Whether or not equity returns remain steady or decline will depend on the balance of the two opposing forces – the desire to hold the new wealth as equity versus the desire for higher return. It is worth noting that without the central bank attempting to sterilise broad money, compared to the first scenario, in addition to the possibility of the loan supply shock ($\mathrm{B^{BS}} \downarrow$ and $\mathrm{D^{R}} \uparrow$ lead to excess liquidity), bond and equity returns are lower. The looser conditions reflect the lack of an accompanying money demand adjustment that was present before, which meant that the non-bank private sector willingly held the full amount of the wealth increase as money.

We consider as a third scenario, a situation where there are non-resident inflows which are invested in existing assets ($\bar{\mathrm{k}} > 0$), purchased from residents (the non-bank private sector and banks); these flows are only invested in bonds and equity, and not broad money. Similar to our second scenario on the trade surplus, the increase in demand by non-residents for an existing pool of assets pushes returns down. The non-bank private sector adjusts its portfolio, increasing broad money holdings as the returns on bonds and equity fall ($\frac{\mathrm{BM}}{\mathrm{W}} \uparrow, \frac{\mathrm{E^R}}{\mathrm{W}} \downarrow, \frac{\mathrm{B^R}}{\mathrm{W}} \downarrow$). The central bank can avoid the fall in bond returns through the issuance of new securities to non-residents ($\mathrm{B^{TD}} \uparrow$ with $\mathrm{BCB} \uparrow$ and $\mathrm{B^{NR}} \uparrow$). If non-residents are indifferent between bonds and equity, and the central bank fully absorbs the inflows, then bond returns are stable and so too are equity returns[36,37]. The BM sterilisation in this case also mitigates the loan supply shock within the banking system.

Table 3.1 provides a brief comparison of the effects across the three scenarios discussed. Overall, from our analysis, several observations can be made in summary.

---

36 It is assumed that the bonds issued are perfectly substitutable for the type of bonds that non-residents demand. This may not be the case in reality. Securities issued for monetary policy and liquidity management purposes tend to be of short-term maturities (as opposed to securities used as collateral for repos, which may display more varying maturities). While we have assumed normal yield curves that move together, there may actually be market segmentation. Furthermore, there is the issue of coordination between government debt management and monetary policy, if the central bank partly relies on government securities for its operations or if both the government and central bank issue securities of similar maturities. In many countries where Treasury bills are actively issued, central banks do not rely on their own bills. See Nyawata (2012) for discussions on the use of central bank bills versus Treasury bills for draining excess liquidity.

37 By similar mechanics, the sale of bonds and equity by non-residents will have upward pressures on bond and equity returns inducing the non-bank private sector and banks to make purchases. The impact on bond and equity returns may be mitigated if there is a reduction in the supply of bonds by way of buyback/redemption by the central bank.

(i) Absorbing the net increase in domestic liquidity from banks as part of operations to keep the short-term policy interest rate target (and base money) stable does not necessarily offset the impact of external inflows on bond and equity returns. Monetary and financial conditions can still be looser, with lower bond and equity returns, and possibly lower retail interest rates among banking institutions due to excess liquidity.

(ii) Absorbing liquidity or sterilising inflows at the source (exporters and non-residents) by increasing the supply of bonds to meet demand can offset the downward pressure on bond and equity returns, and limit the increase in BM and the build-up of excess liquidity among banks.

(iii) However, attempting to induce the non-bank private sector to hold more bonds (and less money) than it wants to would lead to higher bond returns. In our examples, without broad money sterilisation, monetary conditions are increasingly looser as we progressively relax the extent of demand for money. This helps to illustrate the difference between trade surpluses and portfolio capital inflows.

(iv) In all three scenarios, as we move from zero BM sterilisation to full BM sterilisation, the same amount of liquidity is absorbed by the central bank. The difference lies in the sectors which end up as holders of the sterilisation instruments; from banks, to a mix of banks and the non-bank private sector, to just non-residents. On a parallel basis, the addition to banking system excess liquidity is progressively smaller.

(v) The desire to hold assets other than money, changes in supply and/or demand and therefore returns, result in "hot potato" effects, as money gets passed around among agents until there are sufficient changes in returns and prices to equalise demand and supply. BM sterilisation contributes to these effects, unless the bonds supplied fulfil a very specific demand.

At this stage, it is useful to point out the difference between sterilising inflows related to the non-bank private sector and non-residents. With the former, sterilisation bonds still constitute a portion of financial wealth. Wealth has still increased, and the effects of this will still be felt. Furthermore, these bonds are likely to be of short-term maturities. As such, they may constitute monetary assets (having characteristics similar to broad money components) more so than non-monetary assets. At maturity, and with possible shifts in portfolio preferences, these funds may permeate the economy. Higher returns may be required to rollover the sterilisation bonds. In the case of liquidity absorption from non-residents, the channel for wealth increase of the non-bank private sector via the sales of assets to non-residents is shut down.

Table 3.1: Sterilisation of an External Sector Surplus

	Scenario	Without Broad Money Sterilisation	With Broad Money Sterilisation
1.	Trade surplus, $TB = X$. $f_1 > 0, f_2 < 0$ and $f_3 < 0$: The non-bank private sector has corresponding demand for money and no desire to invest in bonds or equity.	$\Delta FXR_{cb} = X$ $\Delta D^R = \Delta BM = X$ No demand for bonds and equity: No change to i^b and i^e. Excess liquidity in the banking system: $\Delta D^R = X$. Liquidity operations with the banking system (net absorption by central bank): $\Delta(B^{BS} + RR + C^{BS}) = X$.	Sterilisation, S>0 Supply of bonds exceeds demand: i^b increase to equalise $\Delta BCB = \Delta B^R$; Demand for equity reduced or stable (fixed supply): i^e increase or stable. $\Delta D^R = \Delta BM = X - \Delta B^R$ Liquidity operations with the banking system (net absorption by central bank): $\Delta(B^{BS} + RR + C^{BS}) = X - \Delta B^R$
2.	Trade surplus, $TB = X$. $f_1 = f_2 = f_3 = 0$: The non-bank private sector apportions the wealth increase equally across money, bonds and equity.	$\Delta FXR_{cb} = X$ $\Delta D^R = \Delta BM = X - Z$: Assume some bonds (Z) purchased from banks ($-\Delta B^{BS}$). Demand for existing bonds and equity: Lower i^b and i^e. Excess liquidity in the banking system: $\Delta D^R + (-\Delta B^{BS}) = X$. Liquidity operations with the banking system (net absorption by central bank): $\Delta(B^{BS} + RR + C^{BS}) = X$.	0<S<1, Demand for bonds met with increased supply, $\Delta BCB=\Delta B^R$: i^b stable; Stable or higher demand for equity (fixed supply): i^e stable or lower. $\Delta D^R = \Delta BM = X - \Delta B^R$ Liquidity operations with the banking system (net absorption by central bank): $\Delta(B^{BS} + RR + C^{BS}) = X - \Delta B^R$
3.	Portfolio capital inflows, $\Delta NK = X$. Non-residents demand for bonds only.	$\Delta FXR_{cb} = X$ $\Delta D^R = \Delta BM = X - Z$; Assume some bonds (Z) purchased from banks ($-\Delta B^{BS}$). Demand for bonds: Lower i^b and i^e. Excess liquidity in the banking system: $\Delta D^R + (-\Delta B^{BS}) = X$. Liquidity operations with the banking system (net absorption by central bank): $\Delta(B^{BS} + RR + C^{BS}) = X$.	S=1, Demand for bonds met with increased supply, $\Delta BCB = \Delta B^{NR}$: i^b and i^e stable. $\Delta D^R = \Delta BM = 0$ Excess liquidity in the banking system =0. No liquidity absorbed from banks; $\Delta BCB = \Delta B^{NR} = X$.

Notes:
It is assumed that for all scenarios, with and without broad money sterilisation, there are no bond or equity sales by non-residents. There are no bond sales by banks in all scenarios with broad money sterilisation.

In Argy and Murray (1985), the analysis indicates that full sterilisation - keeping money supply unchanged, unambiguously raises the interest rate on domestic securities[38], while the effect on equity returns is ambiguous depending on assumptions made about the substitution of different assets in a portfolio. If sterilisation is meant to immunise the domestic real economy from the liquidity effects emanating from the external sector, it would have to be less than complete. This is so because the increases in money represent money demand shocks. Our results are generally consistent with theirs; in particular, our example of the trade surplus which increases money demand. We, however, also consider the cases of trade surplus and capital inflows as money supply shocks. Additionally, we make the distinction between sterilisation at the banks level, which constitutes liquidity management to maintain the policy interest rate, and sterilisation at the non-banks level which constitutes sterilisation of the wider effects of external inflows.

Based on the above, for the next stage of analysis, we make the assumption that there is a desire on the part of exporters and non-residents to channel trade inflows and portfolio capital inflows respectively into bonds. As such, a complete sterilisation of these inflows by supplying the sought after assets offsets their impact on BM and alleviates the downward pressure on bond returns, and at the same time does not cause a rise in returns.

We now consider the impact of intervention, and sterilisation on broad money in the wider context of the model presented in this chapter. Any change in real broad money, $\Delta\mathrm{BM_R}$ is assumed to arise only from real foreign exchange intervention, $\Delta\mathrm{FXR_{Rcbi}}$. We write $\Delta\mathrm{bm_{R,t}}$ which appears in (3.24) as:

$$\Delta\mathrm{bm_{R,t}} = \frac{\Delta\mathrm{BM_{R,t}}}{\mathrm{BM_{R,t-1}}} \tag{3.34}$$

$$\frac{\Delta\mathrm{BM_{R,t}}}{\mathrm{BM_{R,t-1}}} = \frac{\Delta\mathrm{FXR_{Rcbi,t}}}{\mathrm{BM_{R,t-1}}} \tag{3.35}$$

[38] The cases examined are an on-going current account surplus, a fall in the foreign interest rate and an exogenous inflow of foreign capital (a decline in residents' foreign assets). These are instances of surpluses with no direct real effects.

Then, substituting (3.14) into (3.35) gives[39]:

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{Y_{t-1}}{BM_{R,t-1}}\left(\bar{t} + \bar{k} + (\theta + c\varphi)z_t + c\left(i_t - i_t^f\right)\right) \quad (3.36)$$

We next define s as the sterilisation coefficient. When s=1, complete sterilisation occurs, and thus the central bank's intervention operations have no impact on broad money.

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}} \quad (3.37)$$

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{(1-s)Y_{t-1}}{BM_{R,t-1}}\left(\bar{t} + \bar{k} + (\theta + c\varphi)z_t + c\left(i_t - i_t^f\right)\right) \quad (3.38)$$

Setting $v = \frac{Y_{t-1}}{BM_{R,t-1}}$, which is the lagged velocity of money:

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = v(1-s)\left(\bar{t} + \bar{k} + (\theta + c\varphi)z_t + c\left(i_t - i_t^f\right)\right) \quad (3.39)$$

From (3.39), if the central bank is concerned about incomplete sterilisation (s<1), then it would have to consider the impact of the interest rate differential and possible real effective exchange rate disequilibrium on capital flows, particularly if it operates a closely managed exchange rate regime. The effects of these on the interest rate setting decision are more prominent when c is higher. Reducing the degree of intervention and increasing uncertainty about the direction of the exchange rate could alleviate some of the pressure of capital inflows. The central bank would also be concerned about the overheating consequences of large trade inflows driven by an undervalued exchange rate.

---

39 Note $\frac{\Delta BM_{R,t}}{BM_{R,t-1}} \times \frac{Y_{t-1}}{Y_{t-1}} = \frac{\Delta FXR_{Rcbi,t}}{Y_{t-1}} \times \frac{Y_{t-1}}{BM_{R,t-1}}$

We next solve for the monetary policy reaction functions under two cases – with complete sterilisation of trade and capital inflows, and less than complete sterilisation of these inflows.

(b) Monetary policy reaction function with complete sterilisation

Endogenising money, we substitute $\Delta bm_{R,t}$ with $\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}}$ in the augmented output gap equation (3.20), the reduced-form inflation equation (3.21) and the monetary policy reaction function (3.24) to arrive at the following:

$$y_t = \gamma_1 y_{t-1} - \gamma_2 i_t + \gamma_2\left(\lambda\pi_t^T + (1-\lambda)\pi_{t-1} + r_t^*\right) + \gamma_3 z_t + \gamma_4\left[\frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}}\right] + u_{yt} \tag{3.40}$$

$$\pi_t = [\beta_1 + \beta_2(1-\lambda) + \beta_3\gamma_2(1-\lambda)]\pi_{t-1} + (\beta_2 + \beta_3\gamma_2)\lambda\pi_t^T + (1-\beta_1-\beta_2)\left(\Delta e_t + \pi_t^f\right) + \beta_3\gamma_1 y_{t-1} - \beta_3\gamma_2 i_t + \beta_3\gamma_2 r_t^* + \beta_3\gamma_3 z_t + \beta_3\gamma_4\left[\frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}}\right] + \beta_3 u_{yt} + u_{\pi t} \tag{3.41}$$

$$i_t = \left[\frac{\beta_3\left(\beta_1 + \beta_2(1-\lambda)\right)}{\gamma_2({\beta_3}^2+\alpha)} + (1-\lambda)\right]\pi_{t-1} + \left[\frac{\beta_3(\beta_2\lambda - 1)}{\gamma_2({\beta_3}^2+\alpha)} + \lambda\right]\pi_t^T + \frac{\beta_3}{\gamma_2({\beta_3}^2+\alpha)}\left[(1-\beta_1-\beta_2)\left(\Delta e_t + \pi_t^f\right) + u_{\pi t}\right] + \frac{\gamma_1}{\gamma_2} y_{t-1} + r_t^* + \frac{\gamma_3}{\gamma_2} z_t + \frac{\gamma_4}{\gamma_2}\left[\frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}}\right] + \frac{1}{\gamma_2} u_{yt} \tag{3.42}$$

If sterilisation is complete (s=1), (3.42) would be similar to (3.24), with $\Delta bm_{R,t} = 0$. The policy interest rate would also be independent of the foreign interest rate. The difference would be that in (3.42), Δe_t would be smaller than in (3.24), as the central bank intervenes to limit nominal exchange rate volatility. In a fixed exchange rate regime, $\Delta e_t = 0$, which shuts down the direct channel of the exchange rate effect on inflation. However, the effect of the deviation of the real effective exchange rate from its equilibrium level, z_t, remains. In particular, in a fixed exchange rate regime, z_t remains relatively stable at a particular level, which arguably makes the exchange rate more susceptible to disequilibrium and possibly having a greater effect on the output gap than in (3.24). In addition, if for instance, q_t was at an appreciated level relative to q_t^* that is, $z_t < 0$, while based on the reaction function, this would entail a lower policy interest rate, at the same time it would lead to capital outflows. The central bank can support the particular level of the exchange rate with intervention without having to raise interest rates, but risks running down its foreign exchange reserves.

(c) Monetary policy reaction function with incomplete sterilisation

If sterilisation of trade and capital inflows is incomplete, then the policy interest rate would need to rise. To consider the case of incomplete sterilisation more closely, we substitute $\frac{(1-s)\Delta FXR_{Rcbi,t}}{BM_{R,t-1}}$ with its components following (3.39), into (3.40) and (3.41):

$$
\begin{aligned}
y_t = {} & \gamma_1 y_{t-1} \\
& - [\gamma_2 - \gamma_4 v(1-s)c] i_t + \gamma_2 \left(\lambda \pi_t^T + (1-\lambda)\pi_{t-1} + r_t^*\right) \\
& + [\gamma_3 + \gamma_4 v(1-s)(\theta + c\varphi)] z_t \\
& + \gamma_4 v(1-s)\left(\bar{t} + \bar{k}\right) - \gamma_4 v(1-s) c i_t^f + u_{yt}
\end{aligned}
\qquad (3.43)
$$

$$\begin{aligned}\pi_t = {} & [\beta_1 + \beta_2(1-\lambda) + \beta_3\gamma_2(1-\lambda)]\pi_{t-1} + (\beta_2 + \beta_3\gamma_2)\lambda\pi_t^T \\ & + (1-\beta_1-\beta_2)\left(\Delta e_t + \pi_t^f\right) + \beta_3\gamma_1 y_{t-1} - \beta_3[\gamma_2 - \gamma_4 v(1-s)c]i_t \\ & + \beta_3\gamma_2 r_t^* + \beta_3[\gamma_3 + \gamma_4 v(1-s)(\theta + c\varphi)]z_t \\ & + \beta_3\gamma_4 v(1-s)\left(\bar{t} + \bar{k}\right) - \beta_3\gamma_4 v(1-s)ci_t^f + \beta_3 u_{yt} + u_{\pi t}\end{aligned} \tag{3.44}$$

Compared with (3.40) and (3.41), which reflect full sterilisation, three new variables now appear in the output gap equation and reduced-form inflation equation (3.43 and 3.44 respectively) when s<1. These are $\bar{t}$ (exogenous trade flows), $\bar{k}$ (exogenous capital flows), and the foreign interest rate, i_t^f. The first two positively affect the output gap while i_t^f has a negative impact since a lower value leads to more capital inflows. These unsterilised money supply shocks lead to looser monetary conditions with lower bond and equity returns, and possibly lower lending rates with the build-up of excess liquidity in the banking system. While these reflect cheaper financing conditions, from the perspective of savers, the shocks reflect real balance effects including from changes to asset prices, which mirror the lower returns. The extent of the effects are positively influenced by the degree of international asset substitutability, c; lagged broad money velocity, v; and the sensitivity of the output gap to looser monetary conditions, γ_4. At the same time, the effect of the policy interest rate on the output gap is now reduced reflecting the wedge between the policy rate and wider monetary conditions.

We next proceed as before, minimising the loss function to arrive at the monetary policy reaction function:

$$
\begin{aligned}
i_t = &\left[\frac{\beta_3\big(\beta_1+\beta_2(1-\lambda)\big)}{({\beta_3}^2+\alpha)(\gamma_2-\gamma_4 v(1-s)c)}+\frac{\gamma_2}{(\gamma_2-\gamma_4 v(1-s)c)}(1-\lambda)\right]\pi_{t-1} \\
&+\left[\frac{\beta_3(\beta_2\lambda-1)}{({\beta_3}^2+\alpha)(\gamma_2-\gamma_4 v(1-s)c)}+\frac{\gamma_2}{(\gamma_2-\gamma_4 v(1-s)c)}\lambda\right]\pi_t^T \\
&+\frac{\beta_3}{({\beta_3}^2+\alpha)(\gamma_2-\gamma_4 v(1-s)c)}\left[(1-\beta_1-\beta_2)\big(\Delta e_t+\pi_t^f\big)+u_{\pi t}\right] \\
&+\frac{\gamma_1}{(\gamma_2-\gamma_4 v(1-s)c)}y_{t-1}+\frac{\gamma_2}{(\gamma_2-\gamma_4 v(1-s)c)}r_t^* \\
&+\frac{\gamma_3+\gamma_4 v(1-s)(\theta+c\varphi)}{(\gamma_2-\gamma_4 v(1-s)c)}z_t+\frac{\gamma_4 v(1-s)}{(\gamma_2-\gamma_4 v(1-s)c)}\big(\bar{t}+\bar{k}\big) \\
&-\frac{\gamma_4 v(1-s)c}{(\gamma_2-\gamma_4 v(1-s)c)}i_t^f+\frac{1}{(\gamma_2-\gamma_4 v(1-s)c)}u_{yt}
\end{aligned}
\tag{3.45}
$$

As in the earlier two equations, $\bar{t}, \bar{k}$ and i_t^f now appear in the monetary policy reaction function and thus affect the policy interest rate, i_t. The response of i_t to all exogenous variables and shocks is influenced by c, v and γ_4. Higher values of c, v and γ_4 require a stronger policy response compared to the no intervention and full sterilisation scenarios respectively, provided: $0 < \gamma_4 v(1-s)c < \gamma_2$.

The incomplete sterilisation of trade and capital inflows, as discussed in subsection 3.2.6.2(a), implies looser monetary conditions and that the policy interest rate should be higher than it is. The foreign interest rate complicates monetary policy independence, particularly when c is large. A lower foreign interest rate triggers capital inflows, which if incompletely sterilised, entails a higher policy interest rate. If c approaches zero (very low international asset substitutability), then the interest rate differential and perceived disequilibrium in the real effective exchange rate would not induce capital inflows. The foreign interest rate would not matter for the policy interest rate (i_t^f drops out when $c = 0$).

With $0 < \gamma_4 v(1-s)c < \gamma_2$ the policy rate response coefficients are higher on all the predetermined variables affecting the output gap and inflation ($y_{t-1}, r_t^*, z_t, \Delta e_t, \pi_t^f, \pi_t^T, \pi_{t-1}$), and on the aggregate demand and cost-push shocks respectively (u_{yt} and $u_{\pi t}$) compared to the no intervention and intervention with full sterilisation scenarios. The policy interest rate needs to respond more strongly as its effect on the output gap and inflation is partly muted with the incomplete sterilisation of supply-driven broad money growth. Broad money growth serves as a proxy for the wedge between the policy interest rate and actual monetary conditions.

When $\gamma_4 \mathrm{v}(1-\mathrm{s})\mathrm{c} > \gamma_2$, there is a switch in the signs on all coefficients – turning positive for i_t^f and possibly, π_t^T $\left(\text{if } \frac{\beta_3}{\gamma_2(\beta_3{}^2+\alpha)} > \frac{\lambda}{1-\beta_2\lambda}\right)$; while turning negative for all other exogenous variables. The reaction function now indicates that the best policy option is to give up the pursuit of monetary policy independence and have the domestic policy interest rate track the foreign interest rate. This is when the central bank is faced with relatively freely moving capital inflows which cannot be sterilised and which have a strong impact on y_t, whilst the policy interest has a relatively less potent effect (γ_2) on y_t.

Incomplete sterilisation of broad money growth complicates the monetary policy reaction function and makes recourse to additional policy instruments/options more critical. On one hand, complete sterilisation keeps yields on assets relatively stable, which may prolong inflows. On the other, partial sterilisation results in lower yields, which may cause inflows to dissipate. However, domestic monetary conditions are looser with partial sterilisation. The implied stronger policy interest rate response may encourage inflows yet again, which also depend on the real effective exchange rate disequilibrium and foreign interest rates.

An obvious policy option would be to allow greater flexibility in the exchange rate $(\Delta \mathrm{e}_t)$ which alleviates full reliance on the interest rate in the face of aggregate demand and cost-push shocks, and also facilitates adjustments in external inflows. Other alternative policy options include the imposition of capital account restrictions which reduce c and limit the amount of non-resident funds that enter the domestic asset markets. Higher reserve requirements on banks limit the loan supply shock, reflecting forced absorption of liquidity as opposed to the “voluntary” absorption through open market operations and issuance of central bank securities.

3.2.7 Model Extension – Additional Broad Money Determinants

Two key assumptions about the model presented throughout Section 3.2.6 are that only ΔFXR_{cb} drives broad money growth and that it represents money supply shocks. In reality, with regard to broad money determinants, there are two other important elements: changes in banking institutions' net foreign assets (ΔNFA_{bs}) and changes in net domestic assets (ΔNDA_{bm}). Trade surpluses and portfolio capital inflows are reflected in either ΔFXR_{cbi} or ΔNFA_{bs}. More so than portfolio capital inflows, trade inflows can entail corresponding money demand adjustments, since surpluses move in tandem with higher domestic income/wealth. A positive supply shock to ΔNDA_{bm}, which is essentially an increase in the provision of loans by the banking system, leads to a lower lending rate to equilibrate the supply of and demand for credit.

We consider in turn two cases, one with ΔFXR_{cbi} and ΔNDA_{bm} as broad money determinants, and the other with ΔNFA_{bs} and ΔNDA_{bm} as the determinants. For the first case, we express $\Delta bm_{R,t}$ with the determinants in real terms as follows:

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{(1-s)\Delta FXR_{Rcbi,t} + \Delta NDA_{Rbm,t}}{BM_{R,t-1}}$$

$$= v\left[\frac{(1-s)\Delta FXR_{Rcbi,t} + \Delta NDA_{Rbm,t}}{Y_{t-1}}\right] \tag{3.46}$$

$$= v\left[(1-s)\left(\bar{t} + \bar{k} + (\theta + c\varphi)\, z_t + c\left(i_t - i_t^f\right)\right) + \frac{\Delta NDA_{Rbm,t}}{Y_{t-1}}\right] \tag{3.47}$$

We incorporate (3.46) into the monetary policy reaction function to give:

$$\begin{aligned} i_t = {} & \left[\frac{\beta_3\left(\beta_1 + \beta_2(1-\lambda)\right)}{\gamma_2({\beta_3}^2 + \alpha)} + (1-\lambda)\right]\pi_{t-1} + \left[\frac{\beta_3(\beta_2\lambda - 1)}{\gamma_2({\beta_3}^2 + \alpha)} + \lambda\right]\pi_t^T \\ & + \frac{\beta_3}{\gamma_2({\beta_3}^2 + \alpha)}\left[(1 - \beta_1 - \beta_2)\left(\Delta e_t + \pi_t^f\right) + u_{\pi t}\right] + \frac{\gamma_1}{\gamma_2} y_{t-1} + r_t^* \\ & + \frac{\gamma_3}{\gamma_2} z_t + \frac{\gamma_4}{\gamma_2} v\left[\frac{(1-s)\Delta FXR_{Rcbi,t} + \Delta NDA_{Rbm,t}}{Y_{t-1}}\right] + \frac{1}{\gamma_2} u_{yt} \end{aligned} \tag{3.48}$$

As before we assume that full sterilisation (s=1) takes place if the supply of sterilisation bonds meets a specific demand from the non-bank private sector or non-residents – trade and portfolio capital inflows are money supply shocks. If s <1, the issue of whether the external inflows represent money supply or demand shocks is to some extent addressed with the broad money determinants expressed as ratios to Y_{t-1}. $\frac{\Delta FXR_{Rcbi,t} + \Delta NDA_{Rbm,t}}{Y_{t-1}}$ and $\frac{\Delta NDA_{Rbm,t}}{Y_{t-1}}$ are simple money and credit gap measures respectively. If these ratios increase, coupled with high value for lagged velocity, v, the implication is that the policy interest rate should be higher.

While $\frac{\Delta FXR_{Rcbi,t}}{Y_{t-1}}$ captures the wealth/asset effect and cheaper financing conditions associated with external inflows, in particular with regard to bond and equity returns, $\frac{\Delta NDA_{Rbm,t}}{Y_{t-1}}$ captures the actual impact on banking system credit to the non-bank private sector, in terms of loans and bond holdings. The link to external inflows can be observed from equation (3.33). We note that $\Delta NDA_{Rbm,t}$ can increase by the total amount of new deposits less forced absorption that is $\Delta(D^R$- RR).

For the second case, since $\Delta FXR_{cbi,t} + \Delta NFA_{bs,t} = TB_t + \Delta NK_t$, with the additional real broad money determinants, we can write $\Delta bm_{R,t}$ as follows:

$$\frac{\Delta BM_{R,t}}{BM_{R,t-1}} = \frac{\Delta FXR_{Rcbi,t} + \Delta NFA_{Rbs,t} + \Delta NDA_{Rbm,t}}{BM_{R,t-1}}$$

$$= v\left[\frac{\Delta FXR_{Rcbi,t} + \Delta NFA_{Rbs,t} + \Delta NDA_{Rbm,t}}{Y_{t-1}}\right] \tag{3.49}$$

$$= v\left[\bar{t} + \bar{k} + (\theta + c\varphi)z_t + c\left(i_t - i_t^f\right) + \frac{\Delta NDA_{Rbm,t}}{Y_{t-1}}\right] \tag{3.50}$$

We incorporate (3.49) into the monetary policy reaction function but assume $\Delta FXR_{Rcbi,t} = 0$. There is zero foreign exchange intervention and therefore, no sterilisation:

$$i_t = \left[\frac{\beta_3\left(\beta_1 + \beta_2(1-\lambda)\right)}{\gamma_2({\beta_3}^2 + \alpha)} + (1-\lambda)\right]\pi_{t-1} + \left[\frac{\beta_3(\beta_2\lambda - 1)}{\gamma_2({\beta_3}^2 + \alpha)} + \lambda\right]\pi_t^T$$
$$+ \frac{\beta_3}{\gamma_2({\beta_3}^2 + \alpha)}\left[(1-\beta_1-\beta_2)\left(\Delta e_t + \pi_t^f\right) + u_{\pi t}\right] + \frac{\gamma_1}{\gamma_2}y_{t-1} + r_t^*$$
$$+ \frac{\gamma_3}{\gamma_2}z_t + \frac{\gamma_4}{\gamma_2}v\left[\frac{\Delta NFA_{Rbs,t} + \Delta NDA_{Rbm,t}}{Y_{t-1}}\right] + \frac{1}{\gamma_2}u_{yt} \quad (3.51)$$

With $\Delta NFA_{Rbs,t} > 0$ (which leads to exchange rate appreciation), note that the same portfolio adjustments for the non-bank private sector that was discussed in Section 3.2.6(a) still apply. In the respective scenarios of exporters (trade surplus) and non-residents wanting to hold bonds and equity as assets, broad money increases and bond and equity returns fall. The contrast with the case of intervention (with base money sterilisation at the banks level) is that now excess liquidity among banks is reflected in $\Delta NFA_{Rbs,t}$ rather than in domestic currency lending to the central bank ΔC^{BS}. Instead, since the policy interest rate level must be maintained, via monetary operations, central bank domestic currency lending to banks increases. ($C^{BS} \downarrow$ and/or $B^{BS} \downarrow$). The new banking system balance sheet constraint is:

$$NFA_{Rbs,t} + L^{BS} + B^{BS} + (RR + ER) + C^{BS} = D^R \quad (3.52)$$

The loan supply shock is still relevant since D^R is higher[40]. As such, the issue of a wedge between the policy interest rate and wider monetary conditions still remains. Using (3.50) in our loss minimisation problem, we arrive at the following monetary policy reaction function:

[40] For example, assume a trade surplus. $NFA_{Rbs,t}\uparrow$, $C^{BS} \downarrow$ and/or $B^{BS} \downarrow$. The non-bank private sector's deposits/money holdings increase ($D^R \uparrow$). This leads to excess liquidity in the banking system, which is absorbed by the central bank ($C^{BS} \uparrow$ and/or $B^{BS} \uparrow$).

$$
\begin{aligned}
i_t = & \left[\frac{\beta_3\big(\beta_1 + \beta_2(1-\lambda)\big)}{({\beta_3}^2 + \alpha)(\gamma_2 - \gamma_4 vc)} + \frac{\gamma_2}{(\gamma_2 - \gamma_4 vc)}(1-\lambda)\right]\pi_{t-1} \\
& + \left[\frac{\beta_3(\beta_2\lambda - 1)}{({\beta_3}^2 + \alpha)(\gamma_2 - \gamma_4 vc)} + \frac{\gamma_2}{(\gamma_2 - \gamma_4 vc)}\lambda\right]\pi_t^T \\
& + \frac{\beta_3}{({\beta_3}^2 + \alpha)(\gamma_2 - \gamma_4 vc)}\left[(1-\beta_1-\beta_2)\big(\Delta e_t + \pi_t^f\big) + u_{\pi t}\right] \\
& + \frac{\gamma_1}{(\gamma_2 - \gamma_4 vc)} y_{t-1} + \frac{\gamma_2}{(\gamma_2 - \gamma_4 vc)} r_t^* \\
& + \frac{\gamma_3 + \gamma_4 v(1-s)(\theta + c\varphi)}{(\gamma_2 - \gamma_4 vc)} z_t + \frac{\gamma_4 v(1-s)}{(\gamma_2 - \gamma_4 vc)}\big(\bar{t} + \bar{k}\big) \\
& - \frac{\gamma_4 v(1-s)c}{(\gamma_2 - \gamma_4 vc)} i_t^f + \frac{\gamma_4 v}{(\gamma_2 - \gamma_4 vc)}\frac{\Delta NDA_{Rbm,t}}{Y_{t-1}} + \frac{1}{(\gamma_2 - \gamma_4 vc)} u_{yt}
\end{aligned}
\tag{3.53}
$$

The above equation is similar to the monetary policy reaction function in (3.45). The only variations are that we do not include the degree of non-sterilisation of intervention (1-s) and there is now a new variable, $\frac{\Delta NDA_{Rbm,t}}{Y_{t-1}}$. The reaction function indicates that even without foreign exchange intervention, current account surpluses and capital inflows lead to broad money growth and hence looser monetary conditions, which suggest that the policy interest rate should be higher than it is. The key difference is that Δe_t is more volatile, and works as an adjustment mechanism. This may mitigate the persistence element and hence prevent the build-up of imbalances.

3.3 CONCLUSION

The simple model in this chapter offers a fresh perspective by combining the elements of balance of payments flows, foreign exchange intervention and sterilisation within a monetary policy framework where the primary monetary policy instrument is the short-term interest rate. This is consistent with actual practice among central banks, where the liquidity management aspect of monetary policy is carried out so as to keep the operating target for the short-term policy interest rate stable so long as there is no change to the policy stance.

Base money sterilisation does not imply broad money sterilisation. Depending on the instruments used and, crucially, the sectors from which liquidity is absorbed (banks versus non-banks), the central bank's monetary operations have varying implications for broad money growth. Broad money growth, in turn, serves as a proxy for returns on financial assets which matter for aggregate demand, and also reflects real balance effects. As such, broad money growth is indicative of a wedge between the policy interest rate and wider monetary conditions. On this basis, broad money growth is included in the output gap specification. The model presented shows the differences in the optimal monetary policy reaction function when the central bank does not intervene, and intervenes but either completely sterilises or only partially sterilises the impact of balance of payments flows on broad money growth.

With foreign exchange intervention, exchange rate volatility is reduced and there is less need for the central bank to adjust its policy interest rate in response to the effects of nominal exchange rate changes. At the same time however, the central bank still has to be concerned with the possibility of real effective exchange rate disequilibrium. Additionally, using a portfolio balance framework consisting of three assets (broad money, bonds and equity) with intervention as the only source of broad money growth, it is shown that the incomplete sterilisation of intervention drives a wedge between the policy rate and wider monetary conditions as bond and equity returns fall and excess liquidity in the banking system increases. This is provided that balance of payments flows to which intervention is related are not willingly held as money and instead the demand for other assets, given a fixed supply, drives returns down.

With complete broad money sterilisation, by supplying assets to meet demand, the central bank is able to maintain monetary independence and effectiveness, as returns remain stable and there is no increase in banking system excess liquidity. Pressures are asymmetric, however, in the sense that intervention to prevent currency depreciation, as opposed to currency appreciation, runs the risk of running down reserves, and thus raising interest rates may be an inevitable option if a closely managed exchange rate regime is to be maintained.

Incomplete sterilisation reduces monetary policy independence and effectiveness. Three new variables enter the monetary policy reaction function: exogenous trade and capital inflows, and the foreign interest rate. Positive unsterilised money supply shocks lead to looser monetary conditions. The effects are stronger, requiring a larger policy interest rate response, when international asset substitutability, broad money velocity, and the output gap response to broad money growth are high. At the same time, the policy rate response to factors affecting the output gap and inflation needs to be higher than in the complete sterilisation scenario since a wedge has developed between it and wider monetary conditions. An increase in the policy interest rate triggers another round of capital inflows, as the interest rate differential against the foreign interest rate widens. A change in the way the central bank manages its exchange rate and recourse to additional policy instruments become more critical in the incomplete sterilisation scenario.

Extensions to the model to include changes to net foreign assets of banking institutions and changes to broad money net domestic assets indicate that even without intervention, external inflows will still permeate domestic asset markets, and as such a wedge still arises between the policy interest rate and wider monetary conditions. The difference when compared to the scenario of intervention with incomplete sterilisation is that the nominal exchange rate is more volatile and serves as an adjustment mechanism, in which case persistent imbalances are arguably less likely.

In this chapter, we have shown that even if there is base money sterilisation, with liquidity absorbed from banks, balance of payments flows and intervention will still permeate the economy through changes in broad money. Thus, broad money sterilisation is what matters. In Chapters 5 and 6, we estimate the real intervention effects on real base money growth and real broad money growth respectively for our sample of 30 countries. We find that in most countries base money is completely sterilised but broad money is not. According to the model presented here, with incomplete sterilisation of broad money, an inflow of money across the exchanges will require an increase in interest rates in economies operating an interest rate-targeting framework, as is the case in most emerging markets today.

CHAPTER 4

THE EFFECTS OF FOREIGN EXCHANGE INTERVENTION ON MONEY: CONCEPTUAL FRAMEWORK AND EMPIRICAL METHODOLOGY

4.1 INTRODUCTION

Foreign exchange intervention and the nature of sterilisation affect money growth. In turn, theory suggests that money growth has short-to medium-run effects on wider monetary and financial conditions while the long-run link between money and inflation is an accepted empirical phenomenon (see Chapter 3, sections 3.2.5 and 3.2.6.2(a) for discussions on the role of money, and with reference to intervention and sterilisation, respectively).

In this chapter, we seek to provide a conceptual framework and discuss the empirical methodology required to answer the following two questions:

(i) What are the effects of foreign exchange intervention on base money and broad money growth respectively? and

(ii) What are the factors influencing these effects?

In particular, because of the operational elements of the monetary policy framework in most countries, the effect of foreign exchange intervention on base money growth is not expected to be significant unless reserve requirements are an important policy instrument or if the monetary policy framework in operation is a strict currency board or involves base money targeting with either a long-term expansion or quantitative easing mandate.

When the stance of monetary policy is expressed through a short-term interest rate, money market liquidity is managed so as to maintain the policy interest rate at a desired level. The sterilisation of intervention is a by-product of this liquidity management process. In contrast, with a strict currency board, intervention is typically unsterilised. In the case where base money expansion is the focus of policy, the build up in banks' reserve balances with the central bank may reflect unsterilised intervention.

On the other hand, the effect of foreign exchange intervention on broad money growth is expected to be relatively more significant and varied across countries. These variations may occur on account of the development stage of various economies, the types of balance of payment flows and the sectors or agents to which these flows pertain, as well as each country's monetary policy framework and associated sterilisation methods.

The degree of sterilisation in both developed and developing countries has been the subject of extensive literature. However, most of the recent studies tend to focus almost exclusively on base money sterilisation. These studies also do not provide a clear conceptual framework for the mechanisms through which foreign exchange intervention affects both base money and broad money, and are largely silent on the role played by the actual practice of monetary policy implementation by central banks. Consequently, the use of several different types of specifications and estimation methods is prevalent. Furthermore, the thrust of the empirical work is on obtaining the estimates for the sterilisation coefficients with relatively less emphasis on the wider implications of these results. See Chapter 2 for a literature review and *Appendix 1: Selected Recent Studies on Sterilisation in Developing Countries* for further details of selected empirical studies that encompass developing countries.

The rest of this chapter is organised as follows: In Section 4.2, we discuss the theoretical framework and choice of econometric methodology. We describe the specification used in the regression analysis of the effects of foreign exchange intervention, which is based on the monetary approach to the balance of payments and behavioural money demand analysis (Section 4.2.1); discuss issues related to the choice of a proxy for foreign exchange intervention (Section 4.2.2); and address potential questions about the econometric approach (Section 4.2.3). We then provide a detailed explanation of the expected effects of intervention on the money variables, and the consequent hypotheses that are to be tested through the empirical analysis in Chapters 5 and 6 (Section 4.2.4). In Section 4.3, we describe the data and sample choice, and discuss the results from preliminary data testing. We include in this section details of the calculation of our proxy for intervention and a comparison against other possible measures.

4.2 THEORETICAL FRAMEWORK AND ECONOMETRIC METHODOLOGY

4.2.1 The Monetary Approach to the Balance of Payments and Behavioural Money Demand Analysis

In order to assess the effects of changes in the central bank's foreign exchange reserves (the proxy for intervention)[41] on base money and broad money, the money determinants (supply) identity is combined with a behavioural money demand equation. This is based on the monetary approach to the balance of payments, which is essentially taking money market equilibrium and equating money supply with money demand[42]. Such an approach avoids the explicit treatment of either base money or broad money as the monetary policy instrument, and instead allows for more flexibility in the interpretation of coefficients across different monetary policy frameworks.

As discussed in Chapter 2, many recent studies tend to assume net domestic assets of base money as the monetary policy instrument, even when this is not consistent with the reality of monetary policy implementation. The focus thus tends to be on base money sterilisation and the estimating equation is effectively a monetary policy reaction function. An alternative approach is to use a money demand specification. The type of explanatory variables may be similar, for instance measures of output (an output gap measure in the case of a monetary policy reaction function) and inflation. However, the theoretical understanding of the underlying relationship between variables and thus the expected signs on coefficients would differ.

It is the case that while base money is very much within the control of the central bank and thus can be a monetary policy instrument, broad money is a lot less controllable, as it evolves based on the interaction between the central bank, banks and the non-bank sectors. Thus it may function as an intermediate target but not as a monetary policy instrument. It follows that within the context of an interest rate-targeting framework, typically with an interest rate as the monetary policy instrument, or even in an exchange rate targeting framework, it makes conceptual

[41] We discuss the issues pertaining to the measurement of intervention in subsection 4.2.2.2 of this chapter.

[42] See Blejer and Frenkel (2008) for a short overview of the monetary approach to the balance of payments.

sense for the effects of intervention on the monetary aggregates to be measured with some reliance on a money demand specification in the selection of control variables.

The monetary approach to the balance of payments has been used explicitly by Bernstein (2000), who analyses the effects of foreign exchange reserves on base money for a group of six industrial countries. Aizenman and Glick (2009) and Takagi (1991), in analysing sterilisation in emerging market economies, also appear to use simple versions of money demand type specifications. In contrast, Ouyang and Rajan (2011) and Ouyang *et al*. (2008, 2010) use a monetary policy reaction function, derived from a loss minimisation framework based on Brissimis *et al*. (2002), to assess sterilisation and offset coefficients for Singapore and Taiwan individually, a panel group of Asian economies, and China respectively.

We now turn to describing the conceptual framework for analysing the effects of intervention beginning with the following identities for the determinants of base money and broad money.

Change in base money: $\Delta \mathrm{RM_t} = \Delta \mathrm{NDA_{RM,t}} + \Delta \mathrm{NFA_{cb,t}}$ (4.1)

Where

$\Delta \mathrm{NDA_{RM,t}} = \text{the change in net domestic assets of the central bank}$

$\Delta \mathrm{NFA_{cb,t}}$ = the change in net foreign assets of the central bank, which includes the change in foreign exchange reserves, $\Delta \mathrm{FXR_{cb,t}}$

Change in broad money: $\Delta \mathrm{BM_t} = \mathrm{m_t}(\Delta \mathrm{NDA_{RM,t}} + \Delta \mathrm{NFA_{cb,t}}) + \Delta \mathrm{m_t}(\mathrm{RM_t})$ (4.2)

Where m = money multiplier

Broad money can also be expressed as:

$$\Delta \mathrm{BM_t} = \Delta \mathrm{NDA_{BM,t}} + \underbrace{\Delta \mathrm{NFA_{cb,t}} + \Delta \mathrm{NFA_{bs,t}}}_{\text{Balance of payments (BOP) related}} \quad (4.3)$$

Where

$\Delta \mathrm{NDA_{BM,t}}$ = the change in broad money net domestic assets
$\Delta \mathrm{NFA_{bs,t}}$ = the change in net foreign assets of banking institutions

The identity (4.3) in simple terms indicates that growth in broad money supply is driven by domestic credit creation and the balance of payments. When there is foreign exchange intervention, this would be reflected in $\Delta NFA_{cb,t}$ (specifically $\Delta FXR_{cb,t}$) and when there is no intervention, the impact of balance of payments flows would be captured in $\Delta NFA_{bs,t}$. The effects of foreign exchange intervention, and more generally, the effects of balance of payments flows are influenced by the central bank's sterilisation policy. For example, as discussed in Chapter 3, sustained balance of payments inflows, and intervention to limit exchange rate appreciation, lead to liquidity expansion which can fuel further credit creation and also affect market interest rates and asset prices. In an interest rate-targeting framework, sterilisation allows the central bank to mitigate some of these adverse effects and thus be able to focus interest rate policy on domestic economic conditions.

Next, we consider a portfolio-oriented behavioural money demand equation. In equation (4.4) below, which is a variant of equation (3.25), the change in real broad money demand is expressed as a function of income and various opportunity cost variables related to the returns on alternative assets. These explanatory variables are included based on the money demand literature and are discussed in detail in section 4.2.2.1. For ease of illustration, a static equation is used with all variables expressed in change/first difference terms.

$$\Delta m_{d,t} = \beta_0^m + \beta_1^m \Delta y_t + \beta_2^m \Delta i_t^m - \beta_3^m \Delta i_t^a - \beta_4^m \Delta i_t^f + \beta_5^m \Delta er_t - \beta_6^m \Delta \pi_t + \varepsilon_t \tag{4.4}$$

Where,

$\Delta m_{d,t}$ = change in the logarithm of real broad money demand

Δy_t = change in the logarithm of real income

Δi_t^m = change in money's own rate of return

Δi_t^a = change in the rate of return on an alternative domestic asset

Δi_t^f = change in a foreign interest rate

Δer_t = change in the logarithm of the exchange rate

$\Delta \pi_t$ = change in the inflation rate

ε_t = money demand shocks

Then, real foreign exchange intervention, approximated by the change in the central bank's real foreign exchange reserves ($\Delta \text{Real FXR}_{cb,t}$) is incorporated into equation (4.4). Expressing the change in real broad money demand as a growth rate (which is approximately equal to the difference in logarithm values where small changes are concerned) and scaling $\Delta \text{Real FXR}_{cb,t}$ by the level of real broad money lagged one period, we arrive at the following equation:

$$\frac{\Delta \text{Real BM}_{br,t}}{\text{Real BM}_{br,t-1}} = \beta_0^m + \beta_1^m \Delta y_t + \beta_2^m \Delta i_t^m - \beta_3^m \Delta i_t^a - \beta_4^m \Delta i_t^f + \beta_5^m \Delta er_t - \beta_6^m \Delta \pi_t + \beta_7^m \frac{\Delta \text{Real FXR}_{cb,t}}{\text{Real BM}_{br,t-1}} + \varepsilon_t \tag{4.5}$$

Equation (4.5) allows for the estimation of the unique real intervention effects on real broad money change while controlling for demand factors (and viewed another way, factors affecting the non-intervention portion of the money supply determinants, namely $\Delta \text{NDA}_{BM,t}$ and $\Delta \text{NFA}_{bs,t}$). As we illustrated with the simple model in Chapter 3, a lack of broad money sterilisation, particularly when intervention is a money supply shock not matched by demand, can drive a wedge between the policy interest rate and wider monetary and financial conditions as portfolio rebalancing occurs.

Sriram (1999) notes that there exists a consensus that a log-linear specification is the most appropriate functional form for money demand analysis. Thus in (4.4) the money, income and exchange rate variables are typically expressed as logarithms while the interest rate variables are expressed in levels. Meanwhile, the inflation rate is measured as the change in the logarithm of the consumer price index. "Money demand functions are generally specified in real terms on the assumption that the price elasticity of nominal money balances is unity. The implication of this assumption is that the price level changes alone will not cause changes in the demand for real money balances, or alternatively that the demand for nominal balances is proportional to the price level. As such, the public is free from money illusion in its demand for real money balances" - (Sriram, 1999, page 28).

4.2.2 The Choice of Explanatory Variables

4.2.2.1 Traditional Money Demand Determinants

Equation (4.4) in the previous section contains a broad selection of explanatory variables that typically appear in money demand specifications and can be grouped into two types. These are – a scale variable, for example current income to capture transaction demand, or wealth, based on the portfolio approach to money (Santoni, 1987); and measures of the rate of return on money, and the rates of return on alternative assets which together capture the opportunity cost of holding money.

In theoretical portfolio balance models, money is one of several assets in which wealth is held. It is often assumed that while holdings of different assets increase proportionately with wealth, an increase in the level of economic activity is associated with an increase in the demand for money for transaction purposes, requiring a shift out of other assets. Santoni (1987) explains that when current income is not proportional to wealth, then wealth influenced changes in money demand can lead to changes in income velocity, ceteris paribus. However, measuring wealth is not a straight forward task based on either the discounted value of expected future income streams or present value of the stock of net assets. Consequently, the scale variable is usually some measure of national income – GNP, NNP or GDP. Substituting one for another does not present significant differences (Sriram (1999), page 21, quoting Laidler (1993)).

With regard to the opportunity cost of money, this involves some measure of the return on money when the focus is on a broad aggregate; the yields on domestic financial and real assets in a closed economy, and additionally the returns on foreign assets in an open economy setting.

In terms of the returns on alternative domestic financial assets, "researchers adopting a transactions view typically used one or more short-term rates like the yields on government securities, commercial paper, or savings deposits with a notion that these instruments are closer substitutes for money and their yields are especially relevant among the alternatives that are foregone by holding cash. Those considering a less narrow view of the demand for money have used correspondingly a broader set of alternatives including the return on equities, yields on long-term government or corporate bonds" (Sriram, 1999, page 23).

An alternative to including interest rates in levels is to consider interest rate spreads particularly when analysing broad money demand, which has its own rate of return. The role of spreads in money demand does not necessarily refer to the maturity or term structure of interest rates, but to the risk, default and/or liquidity structure of interest rates (Sriram 1999, page 24). In empirical estimation, it should be highlighted that having a spread term implies that the coefficients on the two interest rates are of equal magnitude but have opposite signs.

The return on real assets is generally represented by the expected rate of inflation. Sriram (1999, page 25, quoting Arestis (1988)) notes that when inflationary expectations are strong, economic agents have an incentive to hold real assets rather than money as the real value of money falls with inflation. However, the real value of real assets is maintained. The expected rate of inflation is sometimes the only opportunity cost variable in countries with underdeveloped financial sectors, and in countries experiencing high inflation as the rate of return on alternative financial assets is dominated by the rate of inflation. While some argue that the nominal interest rate is sufficient to capture the expected inflation rate, others argue that the nominal interest rate might not fully incorporate the expected inflation rate when there is some degree of regulation of interest rates (Sriram, 1999, quoting various other studies).

The returns on foreign assets are usually represented by foreign interest rates and the expected rate of depreciation of the domestic currency (Sriram, 1999, page 24). The inclusion of the exchange rate variable is underpinned by the direct currency substitution literature - portfolio shifts between domestic and foreign money occur on account of expectations of changes in the exchange rate. The capital mobility or indirect substitution literature, on the other hand, suggests that the foreign interest rate becomes an important variable especially if foreign securities provide a relevant investment alternative. Some studies do not include the foreign interest rate on the basis that it moves in line with the domestic interest rate; and when both move together, it is the domestic rate that matters for the private sector's demand for money (see for instance, Bahmani-Oskooee (1991)).

The effect of the exchange rate on money demand is mixed. On one hand, as Arango and Nadiri (1981) note, depreciation in the exchange rate would lead to an increase in the wealth of domestic individuals holding foreign securities and investments, and correspondingly domestic money demand. On the other hand, if the currency depreciation leads the public to anticipate further depreciation, then it exerts a negative influence on money demand (there is an increase in the expected return from holding foreign assets). However, if an exchange rate appreciation leads to an anticipation of further appreciation, then the exchange rate appreciation has a positive influence on money demand (Bahmani-Oskooee and Pourheydarian, 1990).

Regarding the extent to which all the explanatory variables associated with the money demand framework are included in the specification for analysis, Sriram (1999, page 28) states, “In theory, all these variables need to be included as the opportunity cost of holding money, in practice various combinations of these variables are attempted in estimating money demand functions. It is an empirical issue.”

If all the possible explanatory variables are included in the money demand specification, multicollinearity is a potential problem. Nevertheless, on the basis of the portfolio balance model, domestic assets are not perfect substitutes with one another, nor are they perfect substitutes with foreign assets. Hence, we would not expect there to be particularly strong correlations between domestic interest rates, and between domestic interest rates, foreign interest rates and the exchange rate. Another concern is that there is likely to be some correlation between $\Delta \mathrm{Real\ FXR}_{\mathrm{cb,t}}$ and the other explanatory variables. Since $\Delta \mathrm{Real\ FXR}_{\mathrm{cb,t}}$ is a policy tool used to manage the exchange rate and thus mirrors some of the balance of payments flows, it is quite possible that it would be correlated with interest rates and income. We do not however, expect the correlations to be high, as these other explanatory variables are influenced by external flows that do not involve intervention, and also by various domestic developments. At the same time, we also do not anticipate a strong relationship between $\Delta \mathrm{Real\ FXR}_{\mathrm{cb,t}}$ and the exchange rate since the former is used to mitigate volatility in the latter.

More generally, there is an important point to note, that is particularly relevant when broad money demand is the subject of analysis. In allocating wealth or income between broad money and alternative assets depending on how the returns on both move, it is important to consider that, assuming credit creation is nil, broad money only increases or decreases if assets shift between the non-bank private sector and banking institutions, non-residents or the government (the money holders exclude non-residents and the government). Thus, outside of these instances, the negative impact of an increase in domestic interest rates on broad money demand, for example, could be capturing the fall in credit creation while the negative impact of higher inflation expectations could be capturing the adverse effects associated with higher inflation.

4.2.2.2 The Proxy for Foreign Exchange Intervention

Attempting to proxy foreign exchange intervention is a standard procedure in the literature, as for many countries, time series data on the central bank's official foreign exchange intervention activity is not readily available. The proxy we use is the change in the US dollar (USD) value of foreign exchange reserves. The level series is available in the International Monetary Fund (IMF)'s International Financial Statistics (IFS) data on central bank accounts. This is the component of the central bank's foreign assets where foreign exchange intervention would be reflected. The IMF definition for foreign exchange reserves is as follows:

Foreign Exchange Reserves includes monetary authorities' claims on non-residents in the form of foreign banknotes, bank deposits, treasury bills, short- and long-term government securities, European Currency Units (ECUs, for periods before January 1999), and other claims that are usable in the event of balance of payments need.

Neely (2000) explains that changes in foreign exchange reserves may not, however, correspond to foreign exchange intervention for several reasons. The value of foreign exchange reserves may change due to revaluation effects arising from changes in the exchange rate, interest income or coupon payments and changes in the value of the underlying asset. Takagi (1991, page 149) states that "official reserves should preferably be valued in foreign currency in order to avoid attributing exchange rate induced valuation changes to the intervention behaviour of authorities." However, if foreign exchange reserves are valued in USD based on conversions from national currency (NC) values (or other foreign currency values), this may address the revaluation changes that have arisen from the NC/USD exchange rate but not the effects arising from changes in the NC (or USD) against other currencies. This is of particular concern if assets are substantially held in foreign currencies other than the USD. Neely (2000) notes that an accurate compensation exercise for such revaluation effects requires knowledge of the currency and asset composition of a country's foreign exchange reserves and the institutional procedures for revaluation.

Foreign exchange reserves may have a poor correlation with actual intervention if reserves are used for transactions other than intervention operations, for example the payment of foreign currency denominated government loans. As Kamil (2008) observes, the distinguishing characteristic of these transactions is that they are not related to influencing the level of the exchange rate. However, one could argue that such transactions alleviate the need for governments to source foreign currency funds from the banking system which in turn would put pressure on exchange rates.

Intervention operations may also not result in corresponding changes in foreign exchange reserves if intervention is deliberately disguised by having nationalised industries conduct transactions and if there are substantial foreign exchange swap operations by the central bank which leads to a discrepancy between intervention and changes in reserves (Neely, 2000).

In the context of analysing the effects of intervention on the growth rates of base money and broad money, three points can be made with regard to the foreign exchange reserves proxy series. One, since intervention is an explanatory variable in the regression analysis, the inclusion of valuation changes will bias the coefficients on intervention effects towards zero as these changes do not constitute intervention that is related to actual private sector inflows and outflows. In particular, interest income may offset declines and exaggerate increases in reserves due to intervention while exchange rate revaluation effects can misrepresent intervention in any direction. Secondly, transactions by nationalised industries, for instance, of keeping foreign currency earnings abroad, do not affect the central bank's foreign exchange reserves and limits the need to create domestic liabilities for sterilisation. Thus, these transactions need not be included in our approximation of central bank intervention. Thirdly, swap operations break the connection between the timing of changes to reserves with actual intervention and the balance of payments flows to which they relate. Consequently, extensive swap operations not accounted for will likely bias the coefficients on intervention effects towards zero. Nevertheless, it is worthwhile to note that reductions in reserves arising from swap operations also entail reductions in domestic liabilities associated with sterilisation of domestic liquidity.

As it stands, there is no one proxy for intervention that is strictly adhered to in the literature that analyses sterilisation. Recent empirical studies tend to use foreign exchange reserves or the broader variable, foreign assets, to proxy intervention, and typically proceed to net off the central bank's foreign liabilities. Foreign assets include items, termed non-currency reserves by Dominguez (2012), such as monetary gold, Special Drawing Rights (SDRs) and the reserve position with the IMF, which may not reflect intervention activity, particularly with regard to "the exchange rate stability motive for reserve accumulation" (Dominguez (2012), page 5)[43]. Changes to non-currency reserves may correspond to changes in foreign exchange reserves when portfolio adjustments between the two take place, thus affecting somewhat the accuracy of the latter as a proxy for intervention. However, these non-currency reserves[44] are also independently affected by factors such as the monetisation or demonetisation of monetary gold, new SDR allocations, changes to IMF quotas, and valuation effects, which in turn, may negate the usefulness of foreign assets as a proxy for intervention. The IMF quota consists of foreign currency and domestic currency components, with the latter not part of the reserve position with the IMF (reserve asset) but still classified as a foreign asset. Foreign assets also include items which have limited usability in the event of balance of payments need, such as claims arising from bilateral payments agreements.

Foreign liabilities include Fund credit (Stand-By or Extended Fund Facility (EFF)); loans from the IMF (for example through the Poverty Reduction and Growth

[43] The IMF (IMF, 2008) provides for the following definition of the central bank's net foreign assets (NFA): NFA = Claims on Non-Residents – Liabilities to Non-Residents.

- Claims on non-residents: monetary gold, SDR holdings, foreign currency, deposits, securities other than shares, loans, financial derivatives, and other items.
- Liabilities to non-residents: deposits, securities other than shares, loans, financial derivatives, and other items.

[44] See IMF (2000, 2008, and 2009) for further explanation on the definitions and balance sheet classifications of non-currency reserves, and transactions with the IMF more generally.

Facility (PGRF)); SDR allocations[45]; deposits of the IMF[46]; and deposits by other central banks, international organisations and non-residents[47]. Fund credit and loans from the IMF work towards meeting payment imbalances and may contribute to changes in foreign exchange reserves. In this regard, changes in foreign exchange reserves may be misinterpreted as active intervention when resources are obtained from the IMF and when repayments are made. Nevertheless, netting off foreign liabilities may introduce additional distortions since it includes other items, which differ across countries, and for which the relevance to foreign exchange intervention cannot be ascertained.

In some instances, adjustments are made to exclude the effects of exchange rate revaluation effects and in other cases, no adjustments are made. Ouyang and Rajan (2011) and Ouyang et al. (2008, 2010), for example, use foreign exchange reserves, net of foreign liabilities, and exclude exchange rate revaluation effects. Even less common are attempts to exclude the interest income on foreign reserves. Wang (2010) assumes for the case of China that all of the country's reserves are invested in US 10-year treasury bonds while an earlier study of Japan, Takagi (1991), uses the average US Treasury bill yield as the rate of return on reserves.

Dominguez (2012), in an analysis of changes to reserves among individual countries during the global financial crisis, notes that the IFS data on the balance of payments subcomponent, USD value of reserve assets, can be used to proxy intervention. This variable is a flow item and thus excludes exchange rate revaluation effects. However, it includes non-currency reserve items. The author compares these data against the changes in international reserves, also available in the balance of payments statistics, to estimate exchange rate revaluation effects. Meanwhile, interest income on reserves is approximated using recently available data from the IMF that allows for the approximation of the asset shares (securities versus deposits)

[45] SDR allocations are the liability entry corresponding to SDR holdings, classified as foreign liabilities beginning 2009. These were previously classified as a component of shares and other equity.

[46] The IMF No.1 Account is the foreign liabilities counterpart to the domestic currency component of the IMF quota subscription.

[47] In some instances, foreign liabilities may include claims by non-residents arising from sterilisation operations, where central bank instruments are held by non-residents rather than banking institutions.

and the currency denomination of reserves[48]. The derived revaluation effects and interest income are then subtracted from the foreign exchange reserves series.

In summary, the foreign exchange reserves series which we use to estimate intervention excludes non-currency reserves and exchange rate revaluation effects. We do not use the net foreign assets series since, given its breadth of subcomponents, this may introduce more distortions to the proxy for intervention compared to the foreign exchange reserves series, which provides for a uniform measure across countries[49]. We also do not exclude interest income on reserves given the lack of related data and information, and to avoid the risk that exclusions based on approximations may compound distortions. We note that by not excluding interest income, some of the reserve accumulation we observe may be purely on account of interest earned rather than a reflection of intervention activity. Finally, we acknowledge that as an alternative, the appropriately adjusted reserve assets series, as highlighted by Dominguez (2012), can be utilised in our analysis. We find, however, that the data are not as extensively available on a time series basis when compared to the foreign exchange series, particularly with regard to the countries in our sample. Further details pertaining to the measurement of the variable we use in our analysis are provided in Section 4.3.

48 The data is available through the IMF's Special Data Dissemination Standard (SDDS) Reserve Template and the Currency Composition of Official Foreign Exchange Reserves (COFER) database. In the former case, the earliest start date of the data for most countries is 2000. The latter provides data only on an aggregate basis. In both instances, there is a limitation in terms of the extent of country coverage.

49 From the aspect of data availability of the net foreign assets series, we find the occasional short series and lack of updates; possible breaks in foreign assets and foreign liabilities arising from the shift to Standardised Report Forms (SRFs); and instances where the foreign assets are smaller than the foreign exchange reserves, which contradicts the reporting structure of the latter being a subset of the former. The data on foreign exchange reserves, on the other hand, appear to be more reliable.

4.2.3 Discussion of Issues Related to the Choice of Econometric Methodology

4.2.3.1 Short Run and Long Run Dynamics of Specification

The current standard procedure to the estimation of money demand involves cointegration analysis and error correction modelling (ECM), allowing for information on the long-run (equilibrium) level relationship between I(1) variables (equation (4.4) but in levels) and analysis of short-run dynamics. The analysis of short-run dynamics may involve a greater number of variables than those that enter the long-run relationship, as the inclusion of exogenous I(0) variables is possible in an unrestricted specification of an ECM.

The Johansen maximum likelihood method (Johansen, 1988), being a multivariate vector autoregressive (VAR) model based approach allows for a consideration of multiple cointegrating relationships as well as tests of weak exogeneity and causality. This is an advantage over the two-step approach of Engle and Granger (1987). In an unrestricted error correction specification or a short-run equation within the vector ECM (VECM), an allowance can be made for the consideration of contemporaneous effects emanating from the regressors on the independent variable. Given the use of maximum likelihood, however, the Johansen method is primarily a technique for large sample testing and analysis. In an economic model of considerable complexity, there are likely to be several cointegrating vectors, which, without prior economic information or theoretical support, can be a source of puzzlement. Such a system is often also sensitive to misspecification. See for instance Wickens (1996) who discusses the problems of interpretation associated with the VECM. The method also usually involves pre-testing the order of integration of the variables involved in the estimation, a task which in itself is also subject to much uncertainty. An alternative methodology developed in more recent times is the Autoregressive Distributed Lag (ARDL) bounds testing for cointegration (Pesaran and Shin, 1999). A key advantage of this method is that it can be employed regardless of whether the underlying variables are I(0), I(1) or fractionally integrated. Additionally, it has been shown that the method produces robust results in small samples (Pesaran and Shin, 1999).

As mentioned, the focus of our empirical analysis are the effects of real intervention, that is the *change* in real foreign exchange reserves ($\Delta\text{Real FXR}_{\text{cb,t}}$)[50], on changes in real base money and real broad money. As such, the more likely equation specification is one made up of variables that are stationary or requiring differencing to become I(0) (hence the expression of equation (4.5) with variables in differences). The focus is not on the relationship between the levels of money and foreign exchange reserves. Appealing to economic theory, one would not necessarily expect there to be a long-run *level* relationship between money and foreign exchange reserves analogous to the relationship between money and the traditional money demand determinants. This is primarily because reserves are a policy variable, the reaction to which is non-standard, and dependent on changing circumstances and active policy manoeuvring. That being said, findings of long-run relationships are nevertheless still plausible (see for example, Bernstein (2000) and Wu (2009) both of whom use the Johansen cointegration method). Furthermore even if reserves do not feature in the long-run relationship, there is a case for evaluating the existence of a more traditional long-run money demand relationship and then estimating the short-run money demand dynamic equation which would include an error correction term as well as $\Delta\text{Real FXR}_{\text{cb,t}}$ and its lags as explanatory variables.

The baseline empirical analysis in section 4.3.2 constitutes dynamic regression analysis using an ARDL approach for individual countries – thus involving a minimum of two regressions (base money and broad money) for each of the 30 countries in our sample. Given the breadth of focus, we choose not to include cointegration analysis, instead, assessing the dynamics between the change in the money variables (change in real base money, $\Delta\text{Real RM}_{\text{res}}$ and change in real broad money, $\Delta\text{Real BM}_{\text{br}}$ respectively) and $\Delta\text{Real FXR}_{\text{cb}}$ along with the change in other money demand factors.

We assume that the relationships between $\Delta\text{Real FXR}_{\text{cb}}$, and $\Delta\text{Real RM}_{\text{res}}$ and $\Delta\text{Real BM}_{\text{br}}$ respectively, are additive in nature, based on the money determinants identity. This contrasts with the standard money demand analysis framework which postulates a multiplicative relationship between most variables.

[50] See for instance Alberola and Serena (2007) who focus on the 'change in' rather than 'level' of foreign assets (FA), explaining that their study is concerned with evaluating the factors affecting reserve accumulation (the change in FA) instead of reserve adequacy (the level of FA).

The additive relationship would thus complicate any assessment of cointegration. The studies that assess cointegration adopt logarithmic transformations of base money, broad money and foreign exchange reserves such that the coefficient estimates for the effects of reserves represent elasticities. Although results appear feasible, this choice of a multiplicative form over an additive representation for these particular variables is perhaps questionable in terms of interpretation and consistency with theory.

The baseline model specification in section 4.3.2 is thus centred on two elements: (1) the short-run effect/contemporaneous effect of $\Delta \text{Real FXR}_{\text{cb}}$ on $\Delta \text{Real RM}_{\text{res}}$ and $\Delta \text{Real BM}_{\text{br}}$ respectively, and (2) the long-run effect of $\Delta \text{Real FXR}_{\text{cb}}$ on $\Delta \text{Real RM}_{\text{res}}$ and $\Delta \text{Real BM}_{\text{br}}$ respectively. The second element can be viewed as a dynamic equilibrium, illustrating the relationship between the growth in foreign exchange reserves and the growth in base money/broad money over time. This contrasts with the static equilibrium that is the equilibrium relationship between levels, within a cointegrating relationship.

4.2.3.2 Regressor Endogeneity

Aside from the possible multicollinearity between explanatory variables as discussed in section 4.2.2 (page 87), there is also the possibility of a much more serious issue, that of the endogeneity of regressors. The direction of causality between real money balances and regressors such as income and domestic interest rates are not entirely clear. For instance, domestic interest rates may be endogenous with respect to supply shocks to real money balances, such as through balance of payments flows.

The literature also discusses the bias that arises from assuming that the change in foreign exchange reserves, $\Delta \text{FXR}_{\text{cb,t}}$ is exogenous in estimations. It is conjectured that changes in the net domestic assets of base money, $\Delta \text{NDA}_{\text{RM,t}}$ (see identity 4.1), indicative of monetary conditions, could in fact lead to changes in $\Delta \text{FXR}_{\text{cb,t}}$. This negative response of $\Delta \text{FXR}_{\text{cb,t}}$ to increases in $\Delta \text{NDA}_{\text{RM,t}}$ in an estimating equation is known as the offset coefficient and is considered a gauge of capital mobility and monetary independence. One way to address the endogeneity of

$\Delta FXR_{cb,t}$ and $\Delta NDA_{RM,t}$ is via appropriate estimation methods for simultaneous equation systems.

For instance, Ouyang and Rajan (2011) and Ouyang et al. (2008, 2010) use two-stage least squares (TSLS). A set of simultaneous equations are specified such that each of the two equations (to estimate the sterilisation and offset coefficients respectively) is just identified. As is the case generally with simultaneous equations, the nature of the identifying restrictions is questionable. The TSLS estimation method can be viewed as a special case of the method of instrumental variables (IV). The IV approach requires the availability of variables that are highly correlated with the endogenous variables $\Delta FXR_{cb,t}$ and $\Delta NDA_{RM,t}$ but not with the errors. Such variables can prove quite difficult to find particularly when lagged values of regressors already form the baseline set of right-hand-side variables in a dynamic specification.

There are however several factors that may render the endogeneity of $\Delta FXR_{cb,t}$ contentious. Firstly, as highlighted, in an interest rate-targeting framework, $\Delta NDA_{RM,t}$ is not the monetary policy instrument, and therefore changes to it do not necessarily imply changes in interest rates that may in turn have effects on capital flows. This is even harder to visualise in the context of broad money net domestic assets, $\Delta NDA_{BM,t}$ (see identity 4.3). Second, reserve accumulation reflects a policy decision with respect to central bank intervention across trade and capital flows depending on the nature of the exchange rate regime. Therefore, changes in $\Delta FXR_{cb,t}$ need not exactly equal changes in capital flows.

Moreover, our empirical analysis focuses on the impact of $\Delta FXR_{cb,t}$ on changes in base money (ΔRM_t) and broad money (ΔBM_t) respectively with an *a priori* expectation of a positive relationship in both instances. A positive causal relationship running from changes in the money variables to $\Delta FXR_{cb,t}$, on the other hand, seems hard to justify on a theoretical basis.

The problem of endogeneity involving more variables can be addressed with VAR models with only lagged values of variables as regressors, whilst still allowing for dynamics. The dynamic structure involved in this method, nevertheless, may not be appropriate when one considers the mechanism of intervention and sterilisation, and the central bank's monetary operations more generally, where the central bank responds immediately to the factors affecting liquidity.

In particular, VAR models would not be able to account for a contemporaneous relationship between intervention and the money variables. On the other hand, lags are sensible in the analysis of the effects of $\Delta FXR_{cb,t}$, particularly on broad money. Depending on the nature of flows and transactions as well as the type of sterilisation, $\Delta FXR_{cb,t}$ may or may not have a contemporaneous effect on changes in broad money. There may however, be subsequent or lagged effects on changes in broad money for instance via an indirect credit creation channel.

Takagi (1999), having not found cointegration in most of the Asian countries studied, proceeds with assessing the effects of foreign assets on the monetary aggregates, M1 and M2, through granger causality and a structural equation, where the first difference of the logarithm of the real money aggregate is regressed on the lagged first difference of the logarithm of real foreign assets (FA), and other explanatory variables including money demand factors, namely income, and interest rate; and seasonal dummy variables. Lagged FA is used "and not current FA, because a change in FA is believed to affect M1 or M2 over time through the banking sector. Use of lagged FA also has an additional advantage in that it alleviates the potential difficulty with M1 or M2 affecting FA contemporaneously" (page 13). The problem with such an approach is precisely that it assumes only an indirect channel of intervention effects and neglects the possibility of important contemporaneous effects. Both, direct and indirect effects and the related relevance of a dynamic structure are theoretically explored in detail in section 4.2.4.

4.2.3.3 Individual Country Regressions versus Panel Data Methods

Panel data methods have several advantages, namely providing efficiency gains by taking into account common structures, increasing degrees of freedom, reducing multicollinearity and removing the impact of some forms of omitted variable bias (Brooks, 2008).

However, basic fixed effects and random effects models have a limitation in that slope homogeneity is assumed for the cross section and over time, even if intercept terms account for omitted variables that vary across entities but are time invariant, or vice versa. "The use of panel techniques rather than estimating separate time series regressions for each object or estimating separate cross sectional regressions for each time period thus implicitly assumes that the efficiency gains from doing so outweigh any biases that may arise in the parameter estimation", (Brooks, 2008, page 490).

Because it is our hypothesis that there are indeed differences in the coefficients on ΔFXR_{cb} across countries and we do not assume one particular type of economic relationship to hold, we utilise individual-country time series regressions in our empirical analysis.

4.2.4 The Effects of Intervention on Base Money and Broad Money: Conceptual Points and Hypotheses for Empirical Analysis

In our Chapter 3 set-up of a simple theoretical model, we presented some of the workings related to base money and broad money sterilisation from the standpoint of an interest rate-targeting framework and using an analysis of portfolio balances (see section 3.2.6.2 of Chapter 3). In this section, we discuss conceptual issues in more detail, and present specific hypotheses which set the stage for the empirical analysis on the effects of intervention on both base money and broad money which we undertake in Chapters 5 and 6 respectively.

4.2.4.1 Issues with Measuring the Effects of Intervention on Base Money

Disyatat (2008, pages 17-18) notes that central banks tend to offset the liquidity impact of their foreign exchange intervention like any other autonomous factor affecting liquidity to maintain aggregate bank reserve balances in line with demand. The idea of partial or incomplete sterilisation thus seems erroneous as central banks either maintain aggregate reserve balances or they do not, with the result being large fluctuations in interest rates in the latter case. As such, he argues, attempts to quantify the degree of base money sterilisation with estimating equations like $\Delta NDA_{RM,t} = \alpha_1 + \beta_1 \Delta NFA_{cb,t} + Z_t + u_{1t}$ are not meaningful exercises. If base money is constant, $\beta_1 = -1$. If base money changes, and to the extent that the factors for these changes are not entirely captured by Z, control variables for money demand, then the coefficient will be different from -1.

Similarly, as noted in Chapter 2, Ho and McCauley (2008) point to many central banks having short-term interest rates as operating targets which leaves quantities, specifically base money, endogenous. The liquidity eventually absorbed would depend on the initial impact on liquidity of all autonomous factors and the central bank's operating objective. Consequently, there is no deliberate sterilisation policy that requires the offsetting of each unit of foreign exchange intervention.

IMF (2011, page 14) interprets full sterilisation as "restoring liquidity conditions to a stance that is in line with the central bank's policy objective. For an inflation-targeting central bank, full sterilisation entails adjusting liquidity post-intervention so as to keep the short-term money market rates close to the policy rate.

In contrast, for a central bank that targets the exchange rate, full sterilisation results in adjusting banks' cash balances so as to keep the relative supplies of domestic foreign and currencies in line with the exchange rate target." It is unclear, but perhaps can be inferred that this study suggests that with an exchange rate target, the effects of intervention on bank reserve balances and interest rates are less of a concern operationally.

Following from the above, we now attempt to provide clarification on several key points about base money expansion. The narrower is the definition for base money, and the less movement there is in the aggregate, then by default there is more likely to be "complete" sterilisation. Base money essentially comprises currency in circulation, required and excess reserves (see equation 4.6 below).

For many countries, currency in circulation is likely to be on a gradual upward trend unless there is a strong demand for cash balances which may be inversely related to the level of financial development. In which case, $\Delta FXR_{cb,t}$ could have a discernible positive effect on currency in circulation, as agents choose to hold some portion of external inflows as cash balances.

$$\Delta NDA_{RM,t} + \Delta NFA_{cb,t} = \underbrace{\Delta CIC_t + \Delta RR_t + \Delta ER_t}_{\Delta RM_t} \qquad (4.6)$$

(CIC = currency in circulation; RR= required reserves; ER = excess reserves)

Required reserves are unlikely to contribute significantly to the size of base money if the reserve requirement ratio is low or not actively used as a policy instrument (in which case, required reserves is endogenous and rises with broad money). If required reserves increase by large amounts, for instance through a policy change, then $\Delta NDA_{RM,t}$ would naturally be lower than otherwise would be the case. This is because any liquidity "locked in" through required reserves or for that matter, voluntarily held in excess reserves, requires less use of open market and open market type operations by the central bank (see Diagrams 4.1 and 4.2 for detailed descriptions of the central bank balance sheet and components of base money).

Excess reserves held by banking institutions are also likely to be relatively small and on a gradual upward trend unless there are extraordinary events that precipitate unusually large precautionary balances. Policy wise, excess reserves may be large if there is deliberate quantitative easing, or a currency board is in operation, in which case, the central bank does not focus on controlling short-term interest rates.

The effects of $\Delta FXR_{cb,t}$ on ΔRM_t are thus influenced by private sector demand for money balances (which affects cash balances, required and excess reserves), actual reserve requirement changes in reaction to $\Delta FXR_{cb,t}$, and the nature of the monetary policy framework.

4.2.4.2 The Usefulness of Measuring the Effects of Intervention on Broad Money

As discussed in section 4.2.4.1, there is a mechanical slant to the effects of $\Delta FXR_{cb,t}$ on ΔRM_t, if we take the view that it primarily concerns liquidity management in the interbank money market and therefore the relationship between the central bank and banking institutions. Furthermore, as shown in Table 3.1 of Chapter 3, regardless of the sector from which liquidity is absorbed (banks versus non-banks), $\Delta NDA_{RM,t}$ responds in a similar manner to (approximately) offset $\Delta FXR_{cb,t}$ leaving base money relatively steady.

In contrast, the analysis of the effects of $\Delta FXR_{cb,t}$ on changes in broad money (ΔBM_t) centres on how intervention related to trade and capital flows permeates the economic system and affects private sector liquidity, depending on the types of balance of payments flows, the sterilisation instruments used, as well as the monetary policy stance. It is possible to have a scenario where $\Delta FXR_{cb,t}$ does not have an impact on ΔRM_t whilst having different implications for ΔBM_t,, and therefore, wider macroeconomic conditions (see sections 3.2.5 and 3.2.6.2 of Chapter 3 for related discussions on the relevance of broad money; and the effects of intervention and sterilisation, respectively).

Important questions include: to what extent does $\Delta FXR_{cb,t}$ drive ΔBM_t directly – via the first-round impact of intervention related to trade and capital flows? To what extent does $\Delta FXR_{cb,t}$ affect ΔBM_t indirectly, through credit creation and spending? How do different sterilisation methods influence these effects and therefore their implications on wider monetary and financial conditions?

The above relates to the distinction that Disyatat (2008, page 18) makes between sterilised intervention and sterilising capital flows. “The former concerns the liquidity impacts of intervention which is a rather moot issue given automatic offsetting operations, while the latter concerns the broader and more pertinent question of how the monetary policy stance may be adjusted to offset the macroeconomic impacts of capital flows.”

The following scenarios explain, from a balance sheet accounting approach, how the kind of transactions that take place, the sectors involved, and the sterilisation methods used, can account for the effects, or lack thereof, of $\Delta FXR_{cb,t}$ on ΔBM_t. Diagram 4.3 which shows the determinants and components of broad money is used to illustrate these points:

i. Liquidity is directly absorbed from non-residents by the central bank in the event of capital inflows, for example through the sales of central bank securities. As such, in Diagram 4.3, NFACB (item 1) increases with the offsetting entry through an increase in central bank securities held by non-residents (item 5). There is no change to BM.

ii. Capital inflows/outflows mainly involve transactions between banking institutions and non-residents.
   - For example, in a scenario of non-resident capital inflows, foreign exchange intervention takes place, raising NFACB, and the inflows are channelled towards the purchase of securities (for example, government securities) from banking institutions. This leads to a reduction in net claims on the central government (item 3 in Diagram 4.3).

iii. Capital inflows/outflows are mainly related to banking institutions, that is, these flows correspond to changes in banking institutions’ external assets and liabilities. There are thus changes to NFACB and NFABS (item 2) in Diagram 4.3 but no change to BM.

iv. Capital inflows/outflows and current account inflows (for instance, commodity related inflows) mainly involve transactions between the central government and non-residents. Consequently, deposits of the central government (item 3 of Diagram 4.3) adjust with changes to NFACB but there is no change to BM.

v. While current account surpluses are expected to lead to broad money growth, intervention need not necessarily have an impact on BM during current account surplus periods.
   - Firstly, there may actually be less intervention when there is a current account surplus compared to a capital inflows episode.
   - Secondly, there could be more use of swap arrangements when there is intervention during current account driven surplus months. Swap arrangements imply smaller changes in NFACB and larger changes in NFABS in Diagram 4.3.

The above points are applicable primarily to contemporaneous effects and to some extent, long-run effects. For instance, in ii, iii and iv, despite the lack of immediate effects, there can still be long-run effects through subsequent credit creation by banking institutions and spending by the government. The effects as discussed are premised on the assumption that broad money is defined to exclude the government, banking institutions and non-residents as money-holding sectors. In essence, while the central bank's liquidity operations with banking institutions in the money market may leave base money relatively unchanged, intervention related to the private sector's current account and capital account flows would still impact on broad money. If sterilisation instruments are held by non-residents, then there would not be an impact on broad money. If instruments are held by the domestic non-bank private sector, and these are included as part of broad money, then there would be an increase in broad money corresponding to intervention. However, in this case, as we analysed in Chapter 3, the indirect effects associated with excess liquidity in banking institutions is less than if liquidity where absorbed from banking institutions.

Diagram 4.1: Stylised Central Bank Balance Sheet[51]

Assets	Liabilities
1 Claims on non-residents	6 Liabilities to non-residents
1.1 Monetary gold and SDR holdings	6.1 Foreign currency deposits from non- residents
1.2 Foreign currency	6.2 Securities other than shares
1.3 Foreign currency deposits	6.3 Loans from non-residents in foreign currency
1.4 Securities other than shares in foreign currency	6.4 Use of IMF facilities
1.5 Foreign currency loans to non-residents	6.5 Other foreign debt
1.6 Other foreign assets	
2 Claims on the central government	7 Liabilities to the central government
2.1 Securities	7.1 Deposits
2.2 Loans and advances	7.2 Other liabilities
2.3 Other claims	
3 Claims on other depository corporations (ODCs)	8 Liabilities to other depository corporations (ODCs)
3.1 Refinancing facilities	8.1 Current accounts (required reserves and excess reserves)
3.2 Repurchase agreements (repos)	
3.3 Other claims	8.2 Vault cash
	8.3 Deposit facilities
	8.4 Reverse repos
	8.5 Other liabilities
4 Claims on other sectors	9 Liabilities to other sectors[52]
4.1 Other financial corporations	9.1 Other financial corporations
4.2 Non financial corporations	9.2 Non financial corporations
4.3 Other resident sectors	9.3 Other resident sectors
	10 Currency in circulation
	11 Central bank securities
	12 Capital and reserves
	13 Revaluation accounts
5 Other assets	14 Other liabilities

[51] Details reflect a combined adaption of presentations in Schaechter (2001, page 11) and IMF (2000, page 87) with minor adjustments by us.

[52] Liabilities to other sectors may comprise of deposits and securities other than shares. These may or may not be included in broad money. If included in broad money, these would also form part of base money (IMF, 2000).

Diagram 4.2: Stylised Determinants and Components of Base Money

<table>
<tr><th>Assets</th><th>Liabilities</th></tr>
<tr><td>Net foreign assets, NFACB (1-6)
Net domestic assets, NDA:
Net claims on the central government (2-7)
+ Net claims on ODCs (3-8.3-8.4-8.5)
+ Net claims on other sectors (4-9)
+ Net other items (5-11-12-13-14)</td><td>Currency in circulation (10)
Monetary reserves (8.1+8.2)</td></tr>
<tr><td>NFACB+NDA=Base money (RM)</td><td>=Base money (RM)</td></tr>
<tr><td colspan="2">Notes:
This summary table is based on items from the full balance sheet detailed in Diagram 4.1.
Money market operations (outright sales and purchases, repos, direct borrowing) are subsumed in net claims on ODCs. In surplus liquidity conditions, money market operations would reflect net borrowing from ODCs.
The issuance of central bank securities is captured in net other items. These are the market based instruments used to manage liquidity depending on the autonomous factors affecting banking system liquidity which includes government flows and changes in NFACB.
Revaluation gains/losses and interest income/payments are reflected in net other items. Thus, for instance, an exchange rate revaluation gain leads to a positive increase in NFACB and a negative increase in net other items.</td></tr>
</table>

Diagram 4.3: Stylised Determinants and Components of Broad Money

<table>
<tr><th colspan="2">Determinant (Assets)</th><th colspan="2">Components (Liabilities)</th></tr>
<tr><td>1
2

3

4
5</td><td>Net foreign assets of the central bank (NFACB)
Net foreign assets of banking Institutions (NFABS)

Net claims on the central government
Loans and advances; securities
less Deposits
Claims on other sectors
Net other items
Central bank securities held by non residents</td><td>6

7</td><td>Currency in circulation

Deposits
(of the domestic non-bank private sector)</td></tr>
<tr><td colspan="2">Broad money net domestic assets, BMNDA = 3+4+5</td><td colspan="2" rowspan="2">= Broad money (BM)</td></tr>
<tr><td colspan="2">NFACB +NFABS + BMNDA
= Broad money (BM)</td></tr>
<tr><td colspan="4">Notes:
Since broad money determinants (assets) to some extent involves the offsetting of counter entries on the balance sheets of the central bank and ODCs respectively, monetary operations that involve these two do not have an impact on broad money. Monetary operations conducted by the central bank involving other sectors (namely the private sector and non-residents) however would have an impact on broad money.</td></tr>
</table>

4.2.4.3 Hypotheses for Empirical Analysis

We now turn to the specific hypotheses that will be investigated through empirical analysis in Chapters 5 and 6. The hypotheses concern the short-run and long-run effects of $\Delta\text{Real FXR}_{\text{cb}}$ on $\Delta\text{Real RM}_{\text{res}}$ and $\Delta\text{Real BM}_{\text{br}}$ respectively.

The effect of $\Delta\text{Real FXR}_{\text{cb}}$ on $\Delta\text{Real RM}_{\text{res}}$ is only expected to be positive and significant if:

(i) reserve requirements are an important policy tool used in reaction to balance of payments flows and foreign exchange intervention;

(ii) there is a policy stance to support money growth via foreign exchange reserves accumulation; or

(iii) the monetary policy framework in operation is that of a strict currency board or involves a monetary base expansion or quantitative easing mandate.

As a baseline prior conjecture, the effect of $\Delta\text{Real FXR}_{\text{cb}}$ on $\Delta\text{Real BM}_{\text{br}}$ is expected to be positive and relatively more significant. However, as discussed in section 4.2.4.2, the effects may not be as straightforward. Transactions between banks or the central government with the rest of the world may not impact broad money, at least not immediately, but may have a long-run impact. While current account surpluses, given the wealth element, are expected to lead to broad money growth; $\Delta\text{Real FXR}_{\text{cb}}$ many not necessarily have an impact on $\Delta\text{Real BM}_{\text{br}}$ if there is less intervention during current account surplus periods. In terms of sterilisation, in some cases central banks may choose to sterilise at the point of the private sector, that is, absorbing liquidity directly from non-bank residents and non-residents, limiting the effect of $\Delta\text{Real FXR}_{\text{cb}}$ on $\Delta\text{Real BM}_{\text{br}}$ (the assumption being that holdings of sterilisation instruments by non-bank residents and non-residents are not part of money). We expect that the relationship between $\Delta\text{Real FXR}_{\text{cb}}$ and $\Delta\text{Real BM}_{\text{br}}$ will be more ambiguous with overall balance of payments deficits ($\Delta\text{Real FXR}_{\text{cb}} < 0$). For instance, capital inflows may impact positively on $\Delta\text{Real BM}_{\text{br}}$, but current account deficits need not have a negative impact, particularly if associated with strong economic growth and increased money demand.

More generally, it is hypothesised that:

(i) The level of economic and financial development matters. A high level of development may render the effects of intervention limited on an already large and domestic asset driven money stock but at the same time may facilitate in the intermediation process and therefore support greater intervention effects on broad money;

(ii) The more persistent is reserve accumulation, the stronger the effects will be on broad money growth, particularly in the long run;

(iii) The use of required reserves and instruments to sterilise liquidity at the point of the private sector will limit intervention effects on broad money; and

(iv) Given the presence of control variables such as income and interest rates, the statistically significant effect of $\Delta \text{Real FXR}_{\text{cb}}$ on $\Delta \text{Real BM}_{\text{br}}$ captures the influence of $\Delta \text{Real FXR}_{\text{cb}}$ that is uniquely different from these other factors that affect the demand for money.

Postulations on the factors for the differences in effects between the short run and the long run are illustrated in Diagrams 4.4 and 4.5.

<u>Diagram 4.4</u>: Hypotheses on Real Intervention Effects on Real Base Money Change

LR	*High LR effect, Low SR effect*	• Increased non-market-based sterilisation in the long run (switch from open market operations to reserve requirements) • Some indirect effects present in the long run (intervention-driven broad money growth leads to base money growth on account of high reserve requirement ratios and increased demand for currency)	• Limited sterilisation (currency board/policy of base money expansion) • Sterilisation of intervention operations through reserve requirements • Some indirect effects due to high reserve requirement ratios	*High SR and LR effects*
	Low LR and SR effects	• Market-based sterilisation • Low reserve requirement ratios	• Limited sterilisation in the short run • Sterilisation through reserve requirements in the short run • Increased market-based sterilisation in the long run (switch from high reserve requirements to open market operations)	*High SR effect, low LR effect*
				SR

SR: short run; LR: long run

Diagram 4.5: Hypotheses on Real Intervention Effects on Real Broad Money Change

LR	*High LR effect, Low SR effect*	• Indirect effects present in the long run (credit creation through banks; public sector spending)	• Intervention related to BOP flows of the non-bank private sector which permeate the economic system in the short run • Indirect effects present in the long run (credit creation through banks; public sector spending)	*High SR and LR effects*
	Low SR and LR effects	• Intervention related to BOP flows that are mainly bank-based or government-related • BOP flows of private sector sterilised (sterilisation instruments held by non-residents/non-bank residents rather than banks) • Limited indirect effects	• Intervention related to BOP flows of the non-bank private sector which permeate the economic system in the short run • Limited indirect effects • Increased sterilisation/monetary tightening in the long run	*High SR effect, low LR effect*
				SR

SR: short run; LR: long run

4.3 DATA DESCRIPTION, MODEL SPECIFICATION AND PRELIMINARY TESTING

4.3.1 Data Description

Table 4.1 contains explanatory notes on the measurement of the variables that are used in the baseline regressions. Specific definitions and sources of data for individual countries are provided in *Appendix 2, Section C: Country Data Notes.*

Of particular note, the change in real foreign exchange reserves, $\Delta \text{Real FXR}_{\text{cb,t}}$, valued in national currency (NC), excludes exchange rate revaluation effects. The starting point of this series is the product of the monthly change in the USD-denominated foreign exchange reserves ($\Delta \text{FXR}_{\text{cb,t}}^{\text{USD}}$) with the average exchange rate during the month ($\text{E}_{\text{t}}^{\text{avg.}}$ = NC/USD)[53]. $\text{E}_{\text{t}}^{\text{avg.}}$ is an approximation for the actual exchange rate corresponding to each transaction during the period.

$$\Delta \text{Real FXR}_{\text{cb,t}} = \Delta\left[\text{FXR}_{\text{cb,t}} \times \frac{100}{\text{CPI}_{\text{t}}}\right]$$

$$= \Delta\left\{\left[\text{FXR}_{\text{cb,T}} + \textstyle\sum_{\text{T}+1}^{\text{t}} \Delta \text{FXR}_{\text{cb,t}}^{\text{USD}} . \text{E}_{\text{t}}^{\text{avg.}}\right] \times \frac{100}{\text{CPI}_{\text{t}}}\right\}$$

where T=1989q1

$$\text{FXR}_{\text{cb,T}} = \text{FXR}_{\text{cb,T}}^{\text{USD}} . \text{E}_{\text{T}} \tag{4.7}$$

A limitation of the above is that we have assumed that all foreign exchange reserves are held in USD assets. However, $\Delta \text{FXR}_{\text{cb,t}}^{\text{USD}}$ potentially includes the exchange rate revaluation effects of the conversion of non-USD-denominated foreign exchange reserves into the USD equivalent. The currency composition of individual countries' foreign exchange reserves is not known. The IMF's COFER database[54] indicates that

---

[53] The national currency value of foreign exchange reserves is given by:
$\text{FXR}_{\text{cb,t}} = \text{FXR}_{\text{cb,t}-1} + \Delta \text{FXR}_{\text{cb,t}}^{\text{USD}} . \text{E}_{\text{t}}^{*} + \text{FXR}_{\text{cb,t}-1}^{\text{USD}}(\text{E}_{\text{t}} - \text{E}_{\text{t}-1}) + \Delta \text{FXR}_{\text{cb,t}}^{\text{USD}}(\text{E}_{\text{t}} - \text{E}_{\text{t}}^{*})$; $\Delta \text{FXR}_{\text{cb,t}}^{\text{USD}} . \text{E}_{\text{t}}^{*} =$ intervention during the period; E_{t} = end period exchange rate; E_{t}^{*} = transaction exchange rate.
Rearranging to exclude exchange rate revaluation effects gives:
$\Delta \text{FXR}_{\text{cb,t}}^{\text{USD}} . \text{E}_{\text{t}}^{*} = \text{FXR}_{\text{cb,t}} - \text{FXR}_{\text{cb,t}-1}\left(1 + \frac{\Delta \text{E}_{\text{t}}}{\text{E}_{\text{t}-1}}\right) - \Delta \text{FXR}_{\text{cb,t}}^{\text{USD}}(\text{E}_{\text{t}} - \text{E}_{\text{t}}^{*})$.
Our adjustment is essentially the left-hand-side of the above equation and is slightly different from the method used in Ouyang and Rajan (2011), Ouyang *et al*. (2008, 2010) and Wang (2010). All of these studies make the adjustment, $\text{FXR}_{\text{cb,t}} - \text{FXR}_{\text{cb,t}-1}\left(1 + \frac{\Delta \text{E}_{\text{t}}}{\text{E}_{\text{t}-1}}\right)$ and appear not to account for $\Delta \text{FXR}_{\text{cb,t}}^{\text{USD}}(\text{E}_{\text{t}} - \text{E}_{\text{t}}^{*})$.

[54] Source: http://www.imf.org/external/np/sta/cofer/eng/index.htm

on an aggregate basis there has been diversification away from USD assets – USD assets represented approximately 60% of reserves in 2010 compared with 75% over 1995-1998. However, the currency composition is only known for a portion of reserves belonging to a segment of countries, and this portion, known as allocated reserves in the database, has dwindled over time.

The common definition of base money across countries is the narrowest form, consisting of currency in circulation and banking institutions' current accounts which encompass required and excess reserves. We indicate in *Appendix 2, Section C: Country Data Notes*, where there are deviations from this definition, for instance, when countries have additional central bank liabilities classified as base money. In general, for each country, the broad money variable reflects the broadest national definition of money that is available, which excludes the central government and non-residents from the money-holding sectors[55]. Non-transferable deposits and securities other than shares account for the predominant portion of broad money components other than currency and demand deposits (IMF, 2000). National definitions of broad money may include repurchase agreements, negotiable certificates of deposits, commercial paper issued by depository corporations, bankers' acceptances, and depending on their liquidity, shares in money market funds. There will, therefore be, differences across countries in the range of financial assets considered as part of broad money.

In the theoretical framework for money demand analysis, it is the expected inflation rate that matters. Here, actual inflation, as measured by the consumer price index (CPI) is used as a proxy for expected inflation.

With regard to capturing foreign influence, many studies do not include both, a foreign interest rate and an exchange rate variable, opting instead to include one or the other, and more commonly the exchange rate (see Tables 1 and 2 of Sriram (2001)). The relevance of a foreign interest rate may be small if the domestic non-bank private sector's investment in foreign assets is limited. Additionally, from the perspective of non-resident flows, there is uncertainty over the most appropriate foreign interest rate that captures the returns on a combination of foreign monetary

[55] The principal money-holding sectors are the same in almost all countries (IMF, 2000). Nevertheless, there may be some exceptions with regard to the classification of government units other than the central government, and non-residents.

and non-monetary assets. Furthermore, non-resident flows influence the domestic non-bank private sector's demand for money through the purchase of domestic non-monetary assets. Thus, the returns on these domestic non-monetary assets are those that matter. As such, for our model specification we include interest rates on domestic money and bonds, as well as an exchange rate variable, but not a foreign interest rate variable.

The exchange rate variable has been represented in numerous ways in the existing literature with no one dominating expression. See Sriram (1999) for details. Here, the real effective exchange rate (REER) is used since it is relevant for competitiveness and the trade balance whilst at the same time having an effect on capital flows via the expectations channel.

All variables have not been seasonally adjusted. This is to avoid the risk of seasonal adjustment affecting the dynamics of the equations being estimated, resulting in a loss of information. See for instance Davidson and MacKinnon (1993) who discuss the views on seasonal adjustment and in particular highlight the problem of biased coefficients arising from the use of linear filters when specifications have lags of the dependent variable. To account for seasonality, a set of seasonal dummy variables are included in the estimating equations.

<u>Table 4.1</u>: General Explanatory Notes on Variables

Variable	Description of Measurement
$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$	Quarterly change in real broad money relative to the real broad money level in the preceding quarter. Real broad money is valued in national currency (NC) and deflated by the CPI.
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	Quarterly change in real base money relative to the real base money level in the preceding quarter. Real base money is valued in NC and deflated by the CPI.
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$	Quarterly change in the central bank's real foreign exchange reserves relative to the real broad money level in the preceding quarter, both valued in NC. The raw foreign exchange reserves (FXR) series is in USD (IFS code: .1D.DZF). The level nominal series in NC, FXR (NC), is derived by sequentially adding monthly nominal changes, which exclude exchange rate revaluation effects, to the 1989q1 level. The monthly change is derived as follows: ΔFXR (NC) = ΔFXR(USD) x $E^{avg.}$ ($E^{avg.}$ =NC/USD, monthly average exchange rate) FXR (NC) is then deflated by the CPI and differenced on a quarterly basis.
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$	Quarterly change in real foreign exchange reserves relative to the real base money level in the preceding quarter. See the previous entry for notes on the measurement of $\Delta\text{Real FXR}_{cb,t}$.
$\Delta\ln(\text{Real GDP})_t$	Quarterly change in the logarithm of gross domestic product (GDP) valued at constant prices (base years vary across countries) / logarithm of nominal GDP deflated by the CPI.
$\Delta\text{IntRate(M)}_t$	Quarterly change in the interest rate on money, typically a time deposit rate which is expressed in percent per annum.
$\Delta\text{IntRate(B)}_t$	Quarterly change in the government/corporate bill/bond rate which is expressed in percent per annum.
$\Delta\ln(\text{REER})_t$	Quarterly change in the logarithm of the real effective exchange rate.
$\Delta(\text{Inflation})_t$	Quarterly change in the annual inflation rate. The annual inflation rate is calculated as the annual change in the logarithm of the CPI, $\ln\text{CPI}_t - \ln\text{CPI}_{t-4}$.

4.3.2 Baseline Model Specification

Individual country estimations are based on quarterly observations over the sample period 1990q1 to 2010q2. This is the maximum sample size, and sample sizes are smaller for some countries due to the lack of availability of long time series data for certain variables. The following are the two standard model specifications estimated for each country.

$$\begin{aligned}
&\Delta \mathrm{Real\ BM}_{br,t}/\mathrm{Real\ BM}_{br,t-1} \\
&\quad = \alpha_0 \\
&\quad + \sum_{i=1}^{4} \alpha_{1i} \Delta \mathrm{Real\ BM}_{br,t-i}/\mathrm{Real\ BM}_{br,t-i-1} \\
&\quad + \sum_{i=0}^{4} \alpha_{2i} \Delta \mathrm{Real\ FXR}_{cb,t-i}/\mathrm{Real\ BM}_{br,t-i-1} + \sum_{i=0}^{4} \alpha_{3i} \Delta \ln(\mathrm{Real\ GDP})_{t-i} \\
&\quad + \sum_{i=0}^{4} \alpha_{4i} \Delta \mathrm{IntRate(M)}_{t-i} \\
&\quad - \sum_{i=0}^{4} \alpha_{5i} \Delta \mathrm{IntRate(B)}_{t-i} + \sum_{i=0}^{4} \alpha_{6i} \Delta \ln\,(\mathrm{REER})_{t-i} - \sum_{i=0}^{4} \alpha_{7i} \Delta(\mathrm{Inflation})_{t-i} \\
&\quad + \varepsilon_{1t}
\end{aligned} \tag{4.8}$$

$$\begin{aligned}
&\Delta \mathrm{Real\ RM}_{res,t}/\mathrm{Real\ RM}_{res,t-1} \\
&\quad = \beta_0 \\
&\quad + \sum_{i=1}^{4} \beta_{1i} \Delta \mathrm{Real\ RM}_{res,t-i}/\mathrm{Real\ RM}_{res,t-i-1} \\
&\quad + \sum_{i=0}^{4} \beta_{2i} \Delta \mathrm{Real\ FXR}_{cb,t-i}/\mathrm{Real\ RM}_{res,t-i-1} + \sum_{i=0}^{4} \beta_{3i} \Delta \ln(\mathrm{Real\ GDP})_{t-i} \\
&\quad - \sum_{i=0}^{4} \beta_{4i} \Delta \mathrm{IntRate(M)}_{t-i} + \sum_{i=0}^{4} \beta_{5i} \Delta \ln\,(\mathrm{REER})_{t-i} - \sum_{i=0}^{4} \beta_{6i} \Delta(\mathrm{Inflation})_{t-i} \\
&\quad + \varepsilon_{2t}
\end{aligned} \tag{4.9}$$

The main results of interest concern the short-run and long-run effects of the growth in real foreign exchange reserves on the growth of real broad money and real base money respectively, that is, the effect of $\Delta\text{Real FXR}_{\text{cb,t}}/\text{Real BM}_{\text{br,t}-1}$ on $\Delta\text{Real BM}_{\text{br,t}}/\text{Real BM}_{\text{br,t}-1}$ in the real broad money regression (equation (4.8)); and the effect of $\Delta\text{Real FXR}_{\text{cb,t}}/\text{Real RM}_{\text{res,t}-1}$ on $\Delta\text{Real RM}_{\text{res,t}}/\text{Real RM}_{\text{res,t}-1}$ in the real base money regression (equation 4.9)). The short-run coefficients are α_{20} and β_{20}, while the long-run coefficients are derived as follows:

$$\alpha_{2,\text{LR}} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i}) \tag{4.10}$$

$$\beta_{2,\text{LR}} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i}) \tag{4.11}$$

Since the regressors and the regressands share the same denominator, the interpretation is that a unit increase in $\Delta\text{Real FXR}_{\text{cb,t}}$ will lead to a change of α_{20} and $\alpha_{2,\text{LR}}$ in broad money in the short-run and long-run respectively; and a change of β_{20} and $\beta_{2,\text{LR}}$ in base money in the short-run and long-run respectively. Generally all these coefficients are expected to have positive signs. The long-run coefficients capture the effects of the growth in foreign exchange reserves which occur indirectly and with a time lag.

Unfortunately theory does not provide much guidance on the appropriate dynamic specification. A lag of up to one year (four lags for each explanatory variable) could perhaps be viewed as plausible and consistent with the horizon of monetary policy, as well as sufficient to take into account of the time needed for banking system intermediation and credit creation to take place. Furthermore, the inclusion of higher order lags is limited by the potential loss of degrees of freedom given the large number of explanatory variables and the small sample sizes. Nevertheless, the inclusion of lagged values of the dependent variable allows for the possibility of changes in the independent variables having effects that persist for longer than there are lags of the independent variables.

With respect to the control variables, in Table 4.2 we list the short-run and long-run coefficients based on equations (4.8) and (4.9) respectively and their expected signs. The coefficients on real GDP, the REER and inflation are elasticities while those on the interest rates are semi-elasticities of base money and broad money growth with respect to the changes in these variables. An increase in the REER reflects appreciation.

<u>Table 4.2</u>: Control Variables in Baseline Model Specification

Control Variables	**Short-run Effect**		**Long-run Effect***		**Expected Sign on Coefficients**	
	Equation		**Equation**		**Equation**	
	(4.8)	(4.9)	(4.8)	(4.9)	(4.8)	(4.9)
Δ ln(Real GDP)	α_{30}	β_{30}	$\alpha_{3,LR} = (\sum_{i=0}^{4} \alpha_{3i}) / X$	$\beta_{3,LR} = (\sum_{i=0}^{4} \beta_{3i}) / Y$	+	+
ΔIntRate(M)	α_{40}	β_{40}	$\alpha_{4,LR} = (\sum_{i=0}^{4} \alpha_{2i}) / X$	$\beta_{4,LR} = (\sum_{i=0}^{4} \beta_{2i}) / Y$	+	−
ΔIntRate(B)	α_{50}	N. A.	$\alpha_{5,LR} = (\sum_{i=0}^{4} \alpha_{5i}) / X$	N. A.	−	N.A.
Δln (REER)	α_{60}	β_{50}	$\alpha_{6,LR} = (\sum_{i=0}^{4} \alpha_{6i}) / X$	$\beta_{5,LR} = (\sum_{i=0}^{4} \beta_{5i}) / Y$	+/−	+/−
Δ(Inflation)	α_{70}	β_{60}	$\alpha_{7,LR} = (\sum_{i=0}^{4} \alpha_{7i}) / X$	$\beta_{6,LR} = (\sum_{i=0}^{4} \beta_{6i}) / Y$	−	−

*Note: X =$(1 - \sum_{i=1}^{4} \alpha_{1i})$; Y=$(1 - \sum_{i=1}^{4} \beta_{1i})$.
N.A.: Not Applicable.

4.3.3 Descriptive Analysis of Foreign Exchange Reserves of Sample Countries

The focus of our study is primarily on emerging market economies with varying degrees of foreign exchange intervention. There are, however, no clear rules on how countries are classified as emerging markets. Our interest lies with developing economies that have embraced market-oriented policies and have relatively significant *de facto* trade and financial openness. We determine our sample of emerging market economies guided by the Morgan Stanley Capital International (MSCI) index for emerging market economies. The MSCI consists of 21 countries[56]. We note that since our analysis period spans two decades, the constituents of the index may not hold historically.

For comparison purposes, we also include advanced economies in our sample which cut across regions and are relatively small, open economies; the exception is Japan, a large open economy, which has accumulated a substantial amount of reserves. Besides Japan, the advanced economies are Australia, Canada, Denmark, Hong Kong, Israel, Japan, New Zealand, Norway and Singapore. The IMF's World Economic Outlook (WEO) database classifies the Czech Republic, Israel, Hong Kong, Korea, Singapore and Taiwan as advanced economies although some of the IMF's research studies (for example, Cardarelli *et al*. (2009)) classify these economies as emerging markets. In our empirical analysis, we group these countries with the emerging market economies.

In Tables 4.3(a) and (b)**,** we indicate the relative degree of accumulation and volatility of changes in foreign exchange reserves held by our sample of 30 countries when considered within a much larger set of countries. On an absolute basis, our sample encompasses the majority of the top 30 reserve-accumulating countries (columns (1) and (2) of Table 4.3(a) which reflect the stock position at end-2010 and accumulation in reserves over 2000-2010 respectively). The chosen economies are interspersed among numerous oil-rich Middle-Eastern and North-African countries, including Saudi Arabia, Algeria, Libya and the United Arab Emirates, as well as

[56] The countries are China, India, Indonesia, Korea, Malaysia, the Philippines, Thailand, Taiwan, Brazil, Chile, Colombia, Mexico, Peru, the Czech Republic, Hungary, Poland, Russia, Egypt, Morocco, South Africa and Turkey. Our group differs slightly as we include Argentina and exclude Morocco.
Source for the countries in the MSCI Index:
http://www.mscibarra.com/products/indices/tools/index_country_membership/emerging_markets.html.
The website was last accessed on 8 June 2010.

several developed economies (namely Switzerland, Sweden, the UK and the US), and a few developing central and eastern European countries. In Table 4.3(b), foreign exchange reserves are scaled by GDP to take into account the relative size of the economies. This alters the relative rankings of reserve accumulation by our sample countries, within the sample itself, and also among the world list of countries. With regard to reserve accumulation world rankings (columns (1) and (2)), the sample countries appear to be more evenly distributed within the list. In column (3), we measure the volatility of changes in reserves which is indicative of two-way intervention to mitigate exchange rate depreciation and appreciation respectively. The countries in our sample are fairly distributed across the rankings, with 18 countries in the top half of the list. The positive and statistically significant correlation coefficient between columns (2) and (3) indicates that countries with higher volatility in reserves also tend to be those that have accumulated reserves, more so in the case of our sample countries compared with the full set of countries.

Table 4.3(a): Size Rankings of Sample Countries' Foreign Exchange Reserves

Sample Countries	Foreign Exchange Reserves (FXR), World Ranking			
	(1) Outstanding Amount, USD billion, end-2010		(2) Change, USD billion, 2000-2010	
Emerging Market Economies				
Asia				
China	2,874.3	1	2,692.7	1
Taiwan	362.4	5	275.8	5
Korea	286.9	6	213.2	8
Hong Kong	268.6	8	172.4	10
India	267.8	9	235.8	7
Singapore	223.7	10	147.2	12
Thailand	165.7	13	131.9	13
Malaysia	102.3	16	72.7	16
Indonesia	90.0	18	63.7	17
Philippines	54.0	23	40.8	22
Latin America				
Brazil	280.6	7	245.3	6
Mexico	114.9	15	83.9	15
Argentina	46.6	27	20.5	38
Peru	41.7	32	32.9	24
Colombia	26.3	41	18.9	41
Chile	26.3	43	12.1	47
Other Emerging Market Economies				
Russia	432.9	3	424.5	3
Poland	86.3	19	60.2	18
Turkey	79.0	20	55.9	19
Israel	69.3	22	46.8	21
Hungary	43.6	29	32.9	25
Czech Republic	40.3	33	27.5	30
South Africa	35.4	35	29.4	28
Egypt	32.4	38	18.1	43
Developed Economies				
Japan	1,036.3	2	758.5	2
Denmark	70.3	21	49.2	20
Norway	49.7	25	27.2	31
Canada	44.9	28	20.5	39
Australia	32.8	37	13.3	46
New Zealand	15.1	49	11.1	50

The data are drawn from the IMF IFS world table on foreign exchange reserves, which reports individual countries' holdings in SDR units. We have converted the amounts into USD based on the USD/SDR exchange rate.
The countries are listed in descending order based on their respective outstanding foreign exchange reserves in column (1).
The rankings in columns (1) and (2) reflect these countries' relative positions, in descending order, among a total of 153 countries. The total number excludes countries with missing values in their data over 2000q1-2010q4.

Table 4.3(b): Size Rankings of Sample Countries' Foreign Exchange Reserves as a percentage of GDP

Sample Countries	Foreign Exchange Reserves (FXR) as % of GDP, World Ranking					
	(1)		(2)		(3)	
	(FXR/GDP) x 100, at end-2010		(ΔFXR/Average GDP) x 100, 2000-2010		(Standard Deviation in Quarterly ΔFXR/ Average GDP) x 100, 2000-2010	
Hong Kong	102.7	1	89.4	8	3.64	15
Singapore	101.5	2	108.3	4	3.65	14
Taiwan	78.7	6	76.0	9	1.90	60
China	57.2	10	102.0	6	2.11	49
Thailand	51.9	15	66.4	13	2.38	41
Malaysia	42.6	17	47.8	22	3.96	10
Israel	35.5	21	32.5	38	1.43	95
Peru	29.1	27	37.0	28	1.89	63
Philippines	26.7	31	34.2	36	1.44	93
Hungary	25.1	34	29.9	42	1.78	71
Korea	25.1	35	27.0	49	1.25	107
Japan	19.9	51	16.7	89	0.64	138
Denmark	19.4	53	18.9	84	1.76	75
Russia	18.5	59	42.3	24	2.92	28
India	17.9	63	27.2	48	1.35	99
Poland	16.8	70	18.7	85	1.30	101
Egypt	16.7	71	15.4	99	0.78	136
Czech Republic	16.6	72	19.9	78	1.20	111
Indonesia	15.3	84	18.9	83	0.87	130
Brazil	15.2	86	23.7	60	0.90	128
Chile	14.7	93	10.0	122	1.05	121
Colombia	12.2	101	14.0	106	0.50	141
Argentina	11.6	109	8.4	129	0.96	125
Mexico	10.9	113	10.6	119	0.49	142
South Africa	10.5	117	13.1	108	0.39	143
Norway	10.4	121	8.6	128	1.10	119
Turkey	9.8	125	11.4	117	0.59	140
New Zealand	9.6	126	10.7	118	1.27	105
Australia	2.8	140	1.8	141	0.85	134
Canada	2.6	142	1.8	142	0.15	144

Correlation (significance level: ***1%, **5%, *10%)		
Columns (1) and (2)	All countries	0.92***
	Sample countries	0.94***
Columns (2) and (3)	All countries	0.61***
	Sample countries	0.79***

The FXR data are drawn from the IMF IFS world table on FXR, which reports individual countries' holdings in SDR units. We have converted the amounts into USD based on the USD/SDR exchange rate.
The GDP data are valued in current prices, USD billion, and are drawn from the IMF WEO Database.
The countries are listed in descending order based on their respective reserves as a percentage of GDP positions in column (1).
The rankings in columns (1), (2), and (3) reflect these countries' relative positions, in descending order among a total of 147 countries. The total number excludes countries with missing values over 2000q1-2010q4 in either their foreign exchange reserves or GDP data.
The standard deviation in column (3) is measured based on the quarterly data of the change foreign exchange reserves over 2000q1-2010q4. The GDP value used as the denominator in column (1) is for 2010, and in columns (2) and (3), it is the average of annual values over 2000-2010.

In Table 4.4, we present the correlation coefficients between different approximate measures of foreign exchange intervention for the countries in our sample. In column (1), we report the correlation coefficients between the change in the national currency value of foreign exchange reserves with and without adjustments for exchange rate revaluation changes (Adjusted $\Delta \mathrm{FXR}_{\mathrm{cb,t}}$ and Unadjusted $\Delta \mathrm{FXR}_{\mathrm{cb,t}}$ respectively). The former is the proxy we use in our empirical analysis of the effects of intervention on base money and broad money growth. The correlations vary across countries, with 20 displaying a correlation of more than 0.50, but only 10 with a correlation of more than 0.75, indicating relatively strong distortions from exchange rate revaluation effects. Some correlations are especially low, namely for South Africa, Korea and Japan. The correlations are influenced by the value of the exchange rate (NC/USD), the extent of exchange rate volatility and the degree of intervention. On one hand, even small revaluation effects on account of a low NC/USD exchange rate can cause divergence in the signs and co-movement of values for the two measures, particularly when there is relatively substantial exchange rate volatility coupled with limited intervention, as is the case for South Africa. On the other hand, large revaluation effects, especially when the value of the NC/USD exchange rate is high, can occur with small amounts of exchange rate volatility but relatively extensive intervention, as in the instances of Korea and Japan. Consequently, while some countries with relatively stable exchange rates against the USD, like Hong Kong and China, exhibit strong correlations; lower exchange rate volatility, as measured by the coefficient of variation, is not strongly associated with a higher correlation coefficient in our sample of countries.[57]

Column (2) contains the correlation coefficients between the change in the national currency value of foreign exchange reserves and the change in the national currency value of net foreign assets, both adjusted for exchange rate revaluation effects (Adjusted $\Delta \mathrm{FXR}_{\mathrm{cb,t}}$ and Adjusted $\Delta \mathrm{NFA}_{\mathrm{cb,t}}$ respectively). Low correlations would primarily reflect the difference in components between the two measures with additional foreign assets and the netting off of foreign liabilities in the latter. The correlations are, however, fairly high across countries, with 20 countries exhibiting a correlation of more than 0.75. There are notably low correlations for Japan and

[57] The correlation coefficient between results in column (1), Table 3.4, and coefficients of variation for NC/USD exchange rates is -0.42, which is statistically significant at the 5% level.

Canada which we attribute to possible misclassification or reporting error since for both, $\mathrm{FXR}_{\mathrm{cb,t}}$ exceeds the gross foreign assets component of $\mathrm{NFA}_{\mathrm{cb,t}}$ several times over.

In column (3) we present the correlation coefficients between the change in the USD value of foreign exchange reserves and the USD value of reserve assets flow from the balance of payments ($\Delta\mathrm{FXR}_{\mathrm{cb,t}}^{\mathrm{USD}}$ and $\Delta\mathrm{RA(BOP)}_{\mathrm{cb,t}}^{\mathrm{USD}}$ respectively). The latter includes flow in non-currency reserves as mentioned earlier. The correlation coefficients serve as a check of the accuracy of the proxy for intervention that we have used. Low correlations can arise from differences in components, and importantly, if a substantial portion of reserves are held in assets denominated in foreign currency other than the USD, the exchange rate revaluation effects for which we have not made an adjustment. We find, however, that the correlation coefficients are relatively high across the countries, with 28 countries displaying a coefficient of more than 0.75. The two exceptions are Norway and Singapore.

Table 4.4: Correlation between Different Approximate Measures of Foreign Exchange Intervention

Country	Correlation Coefficient		
	(1)	(2)	(3)
	Adjusted $\Delta FXR_{cb,t}$ and Unadjusted $\Delta FXR_{cb,t}$	**Adjusted $\Delta FXR_{cb,t}$ and Adjusted $\Delta NFA_{cb,t}$**	**$\Delta FXR^{USD}_{cb,t}$ and $\Delta RA(BOP)^{USD}_{cb,t}$**
	1990m1-2010m6		**1990q1-2010q2**
Argentina	0.81	0.79[a]	0.93
Australia	0.93	0.58	0.98
Brazil	0.49	0.69	0.98
Canada	0.82	0.00	0.86
Chile	0.67	0.97	0.95[b]
China	0.98	0.71	0.99[c]
Colombia	0.33	0.81	0.92[d]
Czech Rep	0.37[e]	0.91[e]	0.78[f]
Denmark	0.90	0.81	0.91
Egypt	0.70	0.29	0.96[g]
Hong Kong	1.00[h]	0.71[h]	0.95[i]
Hungary	0.66	0.76[j]	0.87
India	0.72	0.87	0.83
Indonesia	0.37	0.84	0.92
Israel	0.75	1.00[k]	0.96
Japan	0.29	0.16	0.94
Korea	0.12	0.69	0.96
Malaysia	0.88	0.76	0.95[l]
Mexico	0.63	0.94	0.79
New Zealand	0.85	0.93	0.98
Norway	0.88	0.80[m]	0.64
Peru	0.84	0.89	0.96
Philippines	0.74	0.74	0.92
Poland	0.48	0.85	0.93[n]
Russia	0.58[o]	0.99[o]	0.98[p]
Singapore	0.57	0.99	0.70[q]
South Africa	0.02	0.78	0.89
Taiwan	n.a.[r]	n.a.[r]	0.90
Thailand	0.68	0.93	0.95
Turkey	0.36	0.81	0.92

(1) The adjusted change in the national currency value of foreign exchange reserves which excludes exchange rate revaluation changes (Adjusted $\Delta FXR_{cb,t}$) is equal to $\Delta FXR^{USD}_{cb,t} . E^{avg.}_{t}$.
The unadjusted change in the national currency value of foreign exchange reserves which includes exchange rate revaluation changes (Unadjusted $\Delta FXR_{cb,t}$) is equal to $FXR^{USD}_{cb,t} . E_t$ - $FXR^{USD}_{cb,t-1} . E_{t-1}$.

(2) The adjusted change in the national currency value of net foreign assets which excludes exchange rate revaluation changes (Adjusted $\Delta NFA_{cb,t}$) is equal to $NFA_{cb,t} - NFA_{cb,t-1}\left(1 + \frac{\Delta E_t}{E_{t-1}}\right)$.

(3) $\Delta RA(BOP)^{USD}_{cb,t}$ is the change in reserve assets in USD taken from the balance of payments account and excludes exchange rate revaluation effects.

Unless otherwise indicated below, the correlation coefficients in (1) and (2) are based on monthly data over 1990m1-2010m6, and those in (3) are based on quarterly data over 1990q1-2010q2: (a)1990m2-2010m6, (b)1991q1-2010q2, (c)Annual data, 1990-2009, (d)1996q1-2010q2, (e)1993m2-2010m6, (f)1993q2-2010q2, (g)Annual data, 1990-2009, (h)1997m1-2010m6, (i)1999q1-2010q2, (j)2000m1-2010m6, (k)1990m1-2010m5, (l)1999q1-2010q2, (m)1990m1-2010m4, (n)2000q1-2010q2, (o)1996m1-2010m6, (p)1996q1-2010q2, (q)1995q1-2010q2, (r) End-period exchange rate not available.

4.3.4 Unit Root and Stationarity Tests

The exposition pertaining to the baseline regression specifications presupposes that all the control variables are expressed in first differences to ensure stationarity and that the money growth and intervention variables are indeed stationary. In order to verify the data generating process (DGP) of each of the variables that are meant to enter the estimating equation, two unit root tests and one stationarity test are carried out for all the relevant variables on a country-by-country basis. The unit root tests are the commonly utilised Augmented Dickey-Fuller (ADF) test and the Philips and Perron (PP) test, while the stationarity test is the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test.

An important aspect of the ADF test is the choice of lag length for the lagged difference terms in the test regression. We use the sequential method based on the significance of t-statistics, as advocated by Campbell and Perron (1991), and begin with a lag length of 12. The PP test controls for serial correlation, but can be subject to nontrivial size distortions. Since both the ADF and PP tests tend to have low power against stationary alternative hypotheses that are very close to non-stationarity, the KPSS test, which has trend or level stationarity as the null hypothesis, serves as a check to either confirm or call into question the results of the other two tests.

Two issues that adversely affect the evaluation of the variables' respective DGPs for each country are the relatively short span of data, and the high likelihood of the presence of structural breaks and additive outliers (one-off significant events). The maximum length of the data is 1989q1-2010q2, covering roughly two decades, given that this corresponds to the time period of the empirical analysis, taking into account lag dynamics. Structural breaks can generate spurious non-stationarity while the presence of additive outliers can lead to spurious stationarity (see Perron (1989) and Maddala and Yin (1999)). The time period covered encompasses numerous crises among our sample of countries, for example the Mexican peso crisis in 1994, the Asian financial crisis in 1997, the Russian and Brazilian crises over 1998-1999, the Argentine currency board collapse in 2002, and the global financial crisis of 2007-2009. These events may have led to breaks in our data.

We note that there are unit root tests that allow for break dates to be endogenously determined, thus addressing the issue of uncertainty with regard to the precise timing of shifts in the data. These tests include the Zivot and Andrews (1992) (hereafter referred to as ZA) procedure for a single structural break, and the models of Clemente-Montañés-Reyes (1998) which allow for two mean shifts in the data – the Additive Outliers (AO) model for instantaneous changes in the mean of a series, and the Innovational Outliers (IO) model for gradual shifts in the mean of a series. Since the AO and IO models are essentially for non-trending data, we opt to focus on the procedure developed by ZA as a complementary test to the three basic tests mentioned in the beginning of this section. Although a single break test, the ZA procedure's break-stationary alternative hypothesis allows for changes in level, trend or both.

The tests are performed for variables in levels and first differences for each country. The first difference transformations of the variables reflect the forms used in the regression specifications. The results are detailed in *Appendix 2, Section B: Unit Root and Stationarity Tests for Variables in Levels and First Differences.* See page 284 for the corresponding explanatory notes.

For the variables in levels, the results among the ADF, PP and KPSS tests are mixed, in that there are variables that appear to have unit roots and others which are stationary, and this differs across countries. Furthermore, there are instances of inconsistencies between the three test results. For the variables in first differences, the tests provide relatively more conclusive results. It appears that the ADF test tends to under-reject the null hypothesis of a unit root, although clearly stationarity is more prevalent than unit roots. Both the PP and KPSS tests, however, tend to consistently point to stationarity. The KPSS test, which tests for a unit moving average root, also generally does not suggest overdifferencing of the variables. The ZA test results for break-stationarity in the levels of variables are not noticeably contradictory of the results of the unit root tests without structural breaks, especially when all three of the latter are considered.

From a practical point of view, unit roots in inflation and interest rates raise questions about the policymakers' ability to influence these key monetary policy transmission and goal variables; and draws attention to whether there is mean reversion in the real interest rate. Many of the countries in our sample, however, have undergone significant changes over the last few decades. On one hand, it may be that structural breaks have not been properly pinned down, but on the other, it is also questionable as to whether the forms of DGP have actually remained the same over time. On balance, we err on the side of possibly over-differencing rather than under-differencing by specifying the control variables in first differences, given that the unit root and stationarity tests tend to indicate stationarity in first differences, the dependent variables themselves are growth terms and since we pay attention to checking for serial correlation in the regression residuals.

4.4 CONCLUSION

In this chapter, we provided the background set-up for the empirical analysis of the effects of real foreign exchange intervention on real base money and real broad money respectively. The baseline estimating equations reflect the combination of the monetary approach to the balance of payments and behavioural money demand analysis, rather than monetary policy reaction functions. This avoids treating either of the money variables as explicit policy instruments. The choice of an ARDL specification allows us to capture short-run (contemporaneous) and long-run (indirect) effects of foreign exchange intervention on the money variables. The conceptual framework of how intervention affects the money variables underpins the testable hypotheses, key of which is that intervention will affect broad money differently than base money, with more statistically significant and variable effects expected in the former case.

An important element of the discussion in this chapter was the choice of a proxy for foreign exchange intervention. We use the change in foreign exchange reserves, adjusted to exclude exchange rate revaluation effects (arising from changes in the national currency against the US dollar), and show that the inclusion of these effects can cause significant variations which do not reflect intervention. We have highlighted limitations to our choice, namely that the series is not adjusted for interest income effects, other exchange rate revaluation effects, swap operations and IMF-related transactions. Nevertheless, on balance, it is our assessment that the foreign exchange reserves series is the most suitable proxy for our purposes.

CHAPTER 5

AN EMPIRICAL ANALYSIS OF THE EFFECTS OF FOREIGN EXCHANGE INTERVENTION ON BASE MONEY

5.1 INTRODUCTION

In this chapter, we investigate the effects of real intervention (as measured by the change in real foreign exchange reserves) on changes in real base money as a prelude to the investigation of the effects of intervention on changes in real broad money. In Chapter 4, we provided a detailed conceptual framework and presented our hypothesis that even if the effect of intervention on base money is statistically and economically insignificant, there can still be a significant effect on broad money. The effect of intervention on base money partly depends on the implementation and tactical characteristics of a country's monetary policy framework – namely the choice of operating target and instruments utilised by the central bank. All these important elements have not been adequately addressed in the existing empirical literature. There appears to be a gap between the literature that touches upon the mechanisms of monetary policy implementation, for example Disyatat (2008) and Ho and McCauley (2008), and the literature that focuses on the econometric analysis of intervention effects on base money.

There have been various studies of the effects of intervention on base money in emerging market economies either as the focal point or as a subcomponent of issues related to capital flows and reserve accumulation. However, among these, there are only a few recent studies that cover a group of countries that cut across regions, for example Aizenman and Glick (2009), Cardarelli *et al*. (2009) and Lavigne (2008). The first covers nine countries, of which six are Asian economies and three are Latin American economies; while the second and third encompass 52 and 35 countries respectively. Methods differ across the three studies. Aizenman and Glick (2009) adopt a static multivariate regression specification based on a simple version of the monetary approach to the balance of payments and allow for real GDP and inflation as control variables. Cardarelli *et al*. (2009) use pooled bivariate regressions. Both studies have the change in net domestic assets of base money (ΔNDA) as the dependent variable. Both studies however, do not consider how differences in countries' monetary policy frameworks and choice of instruments, namely reserve requirements, may have affected their estimation results. Lavigne (2008) takes into account the effect of reserve requirements, but uses straightforward ratios, essentially comparing the cumulative change in currency in circulation against the cumulative change in net foreign assets (ΔNFA). Details of the techniques and results of these studies, along with several others, are provided in *Appendix 1: Selected Recent Studies on Sterilisation in Developing Countries.*

Our contribution is to extend the current empirical literature by providing a detailed analysis for a reasonably large and diverse group of 30 countries, supported by a thorough conceptual framework. We carry out multivariate dynamic regression analysis on an individual country basis drawing on the monetary approach to the balance of payments and behavioural money demand analysis in our model specification and choice of control variables. Our approach allows us to disentangle short-run and long-run effects of intervention on changes in base money and to highlight individual country peculiarities which otherwise may distort group-based analysis. Crucially, we are mindful of differences in monetary policy frameworks across countries and conduct tests of possible country characteristics that may account for variations in individual country results.

This chapter is organised as follows: In Section 5.2 we describe our empirical approach briefly, following our extensive discussion in Chapter 4, and then analyse our baseline results in subsection 5.2.1. We draw attention to countries with significant and positive effects of real intervention on changes in real base money. Next, we study the role of different country characteristics in influencing the intervention effects in subsection 5.2.2 by using mean and median equality tests, and bivariate regressions. We also discuss regression diagnostics for the baseline specification of each country and robustness checks in subsections 5.2.3 and 5.2.4 respectively. In Section 5.3, we conclude.

5.2 EMPIRICAL ANALYSIS

As first presented in Chapter 4, the following is the standard model specification estimated with OLS for each country. Our sample consists of 30 countries[58]. Individual country estimations are based on quarterly observations over the sample period 1990q1 to 2010q2. This is the maximum sample size, and sample sizes are smaller for some countries due to the lack of availability of long time series data for certain variables.

$$\begin{aligned}\Delta \text{Real RM}_{\text{res},t}/\text{Real RM}_{\text{res},t-1} &= \beta_0 \\ &+ \sum_{i=1}^{4} \beta_{1i} \Delta \text{Real RM}_{\text{res},t-i}/\text{Real RM}_{\text{res},t-i-1} \\ &+ \sum_{i=0}^{4} \beta_{2i} \Delta \text{Real FXR}_{\text{cb},t-i}/\text{Real RM}_{\text{res},t-i-1} + \sum_{i=0}^{4} \beta_{3i} \Delta \ln(\text{Real GDP})_{t-i} \\ &- \sum_{i=0}^{4} \beta_{4i} \Delta \text{IntRate(M)}_{t-i} + \sum_{i=0}^{4} \beta_{5i} \Delta \ln\,(\text{REER})_{t-i} - \sum_{i=0}^{4} \beta_{6i} \Delta(\text{Inflation})_{t-i} \\ &+ \varepsilon_{2t}\end{aligned} \qquad (5.1)$$

A discussion on the choice of control variables is provided in Chapter 4, section 4.2.2. In section 4.3.2 of the same chapter, we provide descriptions of the variables used in our baseline regression specification and indicate the expected signs on the coefficients. The main coefficients of interest are the short-run and long-run effects of the change in real foreign exchange reserves (intervention) on the change in real base money. The short-run effect is the coefficient β_{20} while the long-run coefficient is derived as follows:

$$\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i}) \qquad (5.2)$$

[58] The countries are Argentina, Australia, Brazil, Canada, Chile, China, Colombia, the Czech Republic, Denmark, Egypt, Hong Kong, Hungary, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Peru, the Philippines, Poland, Russia, Singapore, Taiwan, Thailand and Turkey.

If the coefficients are zero, this indicates that there has been full sterilisation of the intervention operations through market-based instruments. Nevertheless, as noted in previous chapters, there can be incomplete sterilisation, which is different from the inability to carry out sterilisation, when a short-term interest rate is the operating target. This is because intervention is treated like any other factor affecting domestic money market liquidity. The degree of sterilisation is then the outcome of the demand for base money balances (currency, required reserves and excess reserves) by the private sector and banks. This demand is directly linked to the new liquidity associated with the intervention and is not necessarily fully captured by the control variables.

If, on the other hand, the coefficients are closer to one than zero, then this does not necessarily imply that there has been very little sterilisation. Rather, it could be that the domestic liquidity generated through intervention has been absorbed through required reserves. Several of the recent empirical studies are silent on how reserve requirements affect conclusions on the degree of sterilisation (namely Aizenman and Glick (2009), Cardarelli *et al*. (2009) and Ouyang *et al*. (2010)). However, there are also studies that acknowledge the impact of reserve requirements on the size of base money (for example Ho and McCauley (2008), which briefly discusses the case of China in a study on the domestic consequences of reserve accumulation in Asia; and IMF (2011) which contains a short analysis on sterilisation for a group of Asian economies)[59]. A significant positive relationship is possible if reserve requirement ratios are high and used actively in conjunction with increased intervention operations. Frequent movements in the ratios, however, may not be practically desirable among policymakers.

Positive coefficients that are both statistically and economically significant can also occur when the monetary policy framework in operation is a currency board or involves deliberate and continuous monetary expansion. With the former, in the strictest sense, foreign exchange intervention must be allowed to determine the monetary base and interest rate movements, as domestic monetary policy is

[59] Since required reserves constitute a form of sterilisation, one could argue that it should be excluded from the change in base money measure. We do not exclude required reserves for two reasons: (i) the breakdown between required and excess reserves is only available for a few countries whilst any estimation of required reserves requires information on the required reserves ratio(s) and the associated eligible liabilities; and (ii) it provides information on passive sterilisation where the required reserve ratio may be high but is not actively used, and this reflects the endogeneity of base money to broad money.

subjugated to that of the anchor currency country. In the latter case, there is an intentional policy of expanding the monetary base with short-term interest rates falling, perhaps to a level close to zero. Monetary base expansion is a feature of quantitative easing (see for instance Borio and Disyatat (2009) for various characterisations of this policy approach). In both instances, therefore, intervention may lead to corresponding changes in base money. In our sample, we note that Hong Kong has a currency board system[60], whilst Japan undertook prolonged expansionary monetary policy. Japan experienced a marked expansion in base money coupled with falling interest rates in the 1990s and adopted quantitative easing over the period 2001-2006, with its operating target switched from the overnight call rate to current account balances with the central bank.

The unique cases of Hong Kong and Japan aside, among the remaining countries in our sample, 19 countries implemented inflation-targeting during the sample period under investigation and therefore have adopted short-term interest rates as their operating targets. With the other nine countries, Malaysia operates an interest rate-targeting framework and this has been the practice for the greater part of the sample period while Egypt switched to the overnight interest rate as the operational target in 2005 from a monetary-targeting framework previously. The frameworks in Argentina[61], China, India and Taiwan continue to have elements of monetary-targeting with no one interest rate as the main operational target. Meanwhile, Denmark, which has a *de facto* peg to the Euro, operates monetary policy through several key interest rates. Singapore, which has an explicit exchange rate-targeting framework, conducts its money market operations to ensure sufficient liquidity to meet banks' demand for reserve and settlement balances – much like an interest rate-targeting framework, but without the interest rate target. Brief chronological details of each country's monetary policy and exchange rate frameworks are provided in *Appendix 3: Monetary Policy and Exchange Rate Frameworks (1990-2010).*

[60] In our study, we have excluded Exchange Fund Bills and Notes (EFBNs), securities issued by the Hong Kong Monetary Authority (HKMA), from Hong Kong's measure of base money. Although not strictly functioning as sterilisation of intervention, these issuances do provide an avenue for banks to invest their surplus funds (see ADB (2009)). Under the currency board, these liabilities of the HKMA must be fully backed by foreign assets. The data indicates that changes in outstanding EFBNs tend to mimic changes in foreign reserves.

[61] It is commonly accepted that Argentina operated a currency board system over the period 1991-2002, although this is disputed by Hanke (2008).

In summary, the effects of intervention on base money is implicitly about how these effects reflect the deliberate policy of the central bank and/or the outcome of the private sector's actions. Intervention that translates into demand for currency and thus has significant effects on base money need not connote a looser monetary policy than if there were no effect on currency demand, particularly if the increased demand reflects a preference for cash over bank deposits. Meanwhile, sterilisation through required reserves can be either passive or active - the former making base money endogenous to broad money and the way in which liquidity has made its way through the economy. Overall, if the coefficients on intervention effects are small, this need not mean that the liquidity associated with intervention has not had an impact on the economy. At the same time, large positive coefficients do not imply that there is a deliberate policy of non-sterilisation, particularly if reserve requirements are in fact actively used and which to some extent limit increases in the money multiplier and broad money expansion.

5.2.1 Baseline Regression Results for the Real Intervention Effects on Real Base Money Change

The results for each country in Table 5.1 are based on the final parsimonious version of the initial general unrestricted model as presented in equation (5.1). Contemporaneous and lagged values of regressors which were found to be statistically insignificant at the 10% level were removed. The exclusion of variables was done one at a time, in a unidirectional backwards manner, starting with the variable with the highest p-value (or lowest t-statistic) and then proceeding to the next variable with the highest p-value, upon re-estimation of the model. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{\text{cb,t}}/\text{Real RM}_{\text{res,t}-1}$ which is not removed in the general to specific modelling process.

As a general rule, in instances where serial correlation and/or heteroscedasticity had been detected either in the unrestricted model or in the final parsimonious model, robust standard errors were used from the beginning of estimation. The robust standard errors were derived according to either the Newey West HAC or White Consistent Covariances method. Serial correlation was tested for at lags two, four and eight using the Breusch-Godfrey LM test statistic and the F-statistic for the joint significance of lagged residuals. The sample sizes for many of the countries are relatively small, with the smallest sample comprising 46 observations. Finite samples can adversely affect the performance of the LM test and that of the robust standard errors. As such, we use the robust standard errors only when there is consistency between the F-test and the LM test in providing evidence of serial correlation.

The effects of outliers, primarily in the context of non-normality in the residuals, and also in regard to other diagnostic test results, have been removed for some countries with the use of impulse dummy variables. Individual-country regression outcomes along with diagnostic test results are detailed in *Appendix 2, Section A: Detailed Baseline Regression Results.* In subsection 5.2.3 we discuss the results of regression diagnostic tests. In subsection 5.2.4 we elaborate on robustness checks.

For each country, there are two columns of results in Table 5.1. Column (i) consists of the short-run coefficient on $\Delta\text{Real FXR}_{\text{cb,t}}/\text{Real RM}_{\text{res,t}-1}$ while column

(ii) lists the corresponding long-run coefficient. For the short-run coefficients, t-statistics are reported while for the long-run coefficients, F-statistics are reported – both statistics are in brackets.

In Table 5.2, group averages and the average for all countries in the sample are reported. The groups comprise Asia, Latin America, other emerging market economies and developed economies. The results are those of simple averages of the coefficients and their associated average t- and F-statistics.

Table 5.1: Real Intervention Effects on Real Base Money Change - Individual Country Results

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$ (i) Contemporaneous β_{20}	(ii) Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Asia		
China	0.158** [2.638]	0.043 [0.306]
	1991q2-2010q2	
Hong Kong	0.270*** (4.866)	0.155** (4.514)
	1999q1-2010q2	
India	0.157*** (2.860)	0.216*** (22.625)
	1997q1-2010q2	
Indonesia	-0.100 (-1.316)	-0.124 (1.712)
	1995q1-2010q2	
Korea	-0.086** (-2.510)	-0.051** (6.119)
	1991q1-2010q2	
Malaysia	0.041** (2.153)	0.084*** (7.713)
	1990q2-2010q2	
Philippines	-0.076* [-1.983]	-0.076* [3.932]
	1990q2-2010q2	
Singapore	0.008 (0.780)	0.039*** (14.376)
	1990q3-2010q2	
Taiwan	0.074* (1.191)	0.057* (3.678)
	1990q3-2010q2	
Thailand	0.030 [0.855]	-0.017 [0.321]
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i} / (1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ which is not removed in the general to specific modelling process.

<u>Table 5.1</u>: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Latin America		
Argentina	0.116** (2.170)	0.152 (0.889)
	1994q4-2010q2	
Brazil	-0.030 (-0.331)	-0.043 (0.108)
	1997q2-2010q2	
Chile	0.026 (0.943)	0.054* (3.936)
	1990q4-2010q2	
Colombia	0.144* [1.982]	0.362*** [24.377]
	1995q2-2010q2	
Mexico	-0.062*** (-3.231)	-0.046*** (10.667)
	1991q2-2010q2	
Peru	0.030*** (3.120)	0.120*** (86.527)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i} / (1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$which is not removed in the general to specific modelling process.

<u>Table 5.1</u>: Continued

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR}=\sum_{i=0}^{4}\beta_{2i}\Big/(1-\sum_{i=1}^{4}\beta_{1i})$
Other Emerging Market Economies(EMEs)-Europe, Middle East and Africa		
Czech Republic	0.069* (1.760)	0.048* (3.105)
	1997q2-2010q2	
Egypt	3.537*** (7.867)	1.934** (6.221)
	2003q1-2010q2	
Hungary	0.035 (1.243)	0.090*** (8.381)
	1996q1-2010q2	
Israel	0.563*** {5.714}	0.688*** {26.408}
	1990q4-2010q2	
Poland	-0.011 [-0.142]	0.113 [1.166]
	1997q3-2010q2	
Russia	0.264*** [3.041]	0.253*** [10.548]
	1996q3-2010q2	
South Africa	0.057 (1.085)	0.084** (5.144)
	1991q2-2010q2	
Turkey	-0.012 (-0.309)	-0.012 (0.096)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4}\beta_{2i}/(1-\sum_{i=1}^{4}\beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ which is not removed in the general to specific modelling process.

<u>Table 5.1</u>: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Developed Economies		
Australia	-0.011 (-0.062)	-0.007 (0.004)
	1991q2-2010q2	
Canada	0.027 (0.781)	0.055** (4.811)
	1990q4-2010q2	
Denmark	-0.015 (-0.736)	-0.008 (0.536)
	1991q1-2010q2	
Japan	0.425** [2.092]	0.636** [4.612]
	1990q2-2010q2	
New Zealand	0.046 (1.497)	0.278*** (18.260)
	1991q1-2010q2	
Norway	0.034 (0.779)	0.024 (0.605)
	1991q1-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t- and F-statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ which is not removed in the general to specific modelling process.

<u>Table 5.2</u>: Real Intervention Effects on Real Base Money Change - Group Averages

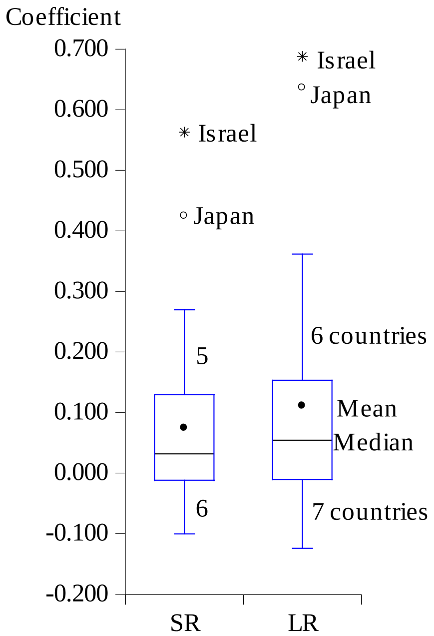
Group	The group average effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4}\beta_{2i} \Big/ (1-\sum_{i=1}^{4}\beta_{1i})$
Asia	0.048* (1.845)	0.033** (6.530)
Excluding Taiwan	*0.045** *(1.917)*	*0.030**** *(6.846)*
Latin America	0.037* (1.868)	0.101*** (21.084)
Other EMEs	0.563*** (2.610)	0.400*** (7.634)
Excluding Egypt	*0.138** *(1.858)*	*0.181**** *(7.835)*
Developed Economies	0.084 (0.991)	0.163** (4.805)
TOTAL	**0.190*** **(1.882)**	**0.170***** **(9.390)**
Excluding Taiwan and Egypt	***0.075**** ***(1.693)***	***0.111****** ***(9.707)***
Sample standard deviation (excluding Taiwan and Egypt)	*0.151*	*0.191*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average t-statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4}\beta_{2i}/(1-\sum_{i=1}^{4}\beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$which is not removed in the general to specific modelling process.
- Results are reported for average values which exclude Egypt and Taiwan. The former is an outlier in the analysis of intervention effects on real base money growth and the latter, and outlier in the analysis of intervention effects on real broad money growth.

With reference to Tables 5.1 and 5.2, the results indicate that the effect of real intervention on the change in real base money is on average, low. Excluding Taiwan and Egypt[62], the average coefficients for the remaining sample of 28 countries are 0.075 in the short-run and 0.111 in the long-run respectively. In effect, a one unit increase in real intervention only leads to a 0.075 unit increase in the change in real base money in the short run and a 0.111 unit increase in the long run. However, the corresponding standard deviations across the sample group are 0.151 and 0.191 respectively, which suggests substantial dispersion. On closer inspection, the short-run and long-run coefficients are in the range of 0.000 – 0.200 for about half of the countries (15 and 13 respectively), and negative in value for nine countries. Nevertheless, the negative coefficients tend to be of small economic significance even if statistically significant. Israel and Japan are outliers on the other end of the spectrum with statistically significant positive short-run and long-run coefficients of 0.563 and 0.688, and 0.425 and 0.636 respectively. The dispersions in the short-run and long-run coefficients across countries are summarised in the following boxplots (Graph 5.1).

[62] We exclude Egypt as the short-run and long-run coefficients are exceptionally large and based upon regressions covering a short sample period. The sample period differs considerably from that which is used in the real broad money growth regression in Chapter 6. In the case of Taiwan, while the coefficients in this chapter do not represent outliers, the long-run coefficient from the real broad money regression is exceptionally large and statistically insignificant in Chapter 6 and Taiwan is excluded in that chapter's analysis. In order to have the same sample of countries when we compare the coefficients from the real base money growth regression against those from the real broad money growth regression later, we thus exclude both these countries in our analysis here as well as in the next chapter.

<u>Graph 5.1</u>: Boxplots for the Short-run and Long-run Real Intervention Effects on Real Base Money Change



Note: Box encloses middle 50% of the observations.

It is difficult to make one-to-one comparisons with the results of previous empirical work owing to differences in country coverage, methodology and sample period. Nevertheless, if we take a subset of the countries in our sample which is comparable to the set of countries in other studies and if there are substantial differences in results, then this highlights the importance of the choice of methodology, variations in the effects of intervention over time and also, possibly, differences in data definitions.

In particular, we compare the average of the long-run coefficient for the subset of the countries[63] in our sample which is consistent with the sample in Aizenman and Glick (2009) against their results which are based on static multivariate regressions using quarterly overlapping annual observations. At a statistically significant 0.042, our result is reasonably consistent with the high

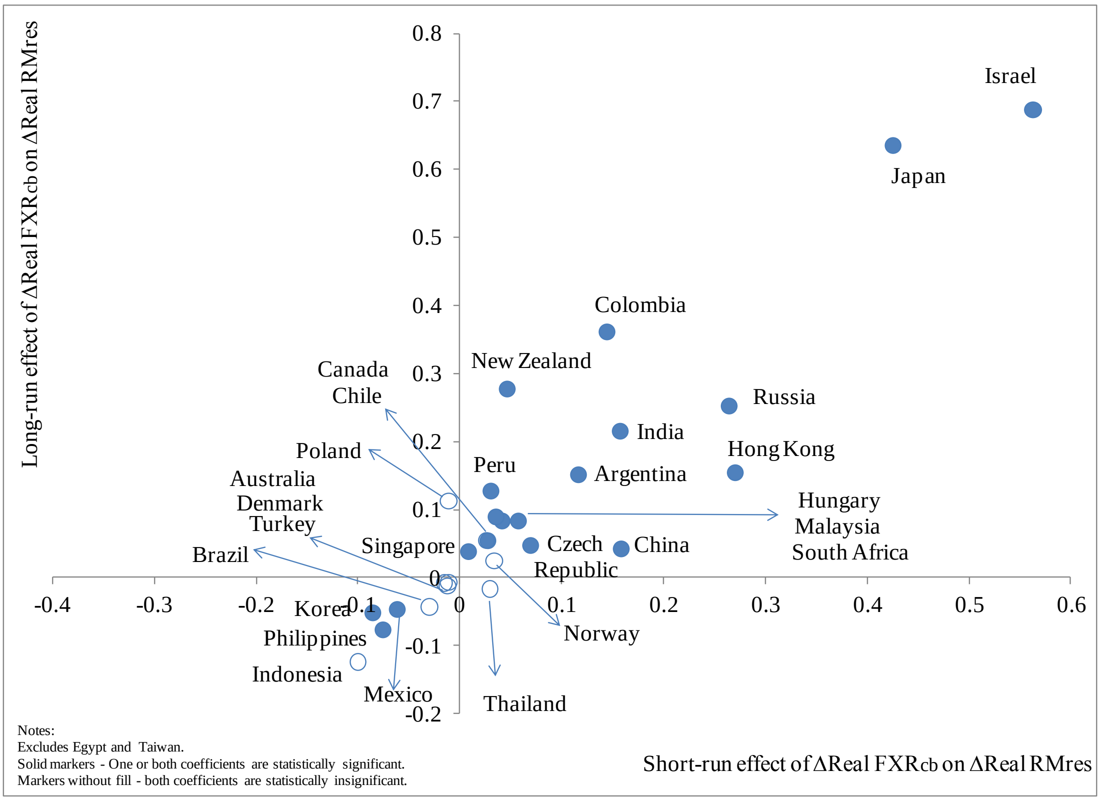
[63] The countries are Argentina, Brazil, China, India, Korea, Malaysia, Mexico, Singapore and Thailand.

statistically significant sterilisation coefficients Aizenman and Glick (2009) report which we average to arrive at -0.825 and -0.996 (pre- and post-break respectively).

Our results are much less consistent with those of Lavigne (2008) and Cardarelli *et al*. (2009) since these are based on ratios of cumulative amounts and annual sterilisation coefficients drawn from bivariate regressions of pooled monthly data respectively. The sterilisation coefficients from these studies tend to be lower than what would be suggested by our intervention effects partly on account of the simplicity of methodology employed in these studies.

In Graph 5.2 we plot the long-run coefficients against the short-run coefficients and in Table 5.3 we provide the results of regressions between these two variables. A unit increase in the short-run coefficient implies roughly a unit increase in the long-run coefficient. With reference to Diagram 4.4 of Chapter 4, this suggests that countries are generally in the bottom left or top right quadrants of the diagram – that is they belong to either the category of countries with low reserve requirement ratios and/or market based sterilisation of intervention; or the category of countries with active use of reserve requirements to sterilise intervention or which operate frameworks with limited sterilisation of intervention.

<u>Graph 5.2</u>: The Relationship between Short-run and Long-run Effects of Real Intervention on Real Base Money Change



<u>Table 5.3</u>: Regression Analysis between Short-run and Long-run Effects of Real Intervention on Real Base Money Change

Regressor: Short-run Coefficient	Dependent variable: Long-run Coefficient		
	Coefficient	**t-statistic**	**Adjusted R^2**
All countries	1.148	10.797***	0.81
Excluding Israel and Japan	0.903	5.406***	0.53

Note: The maximum number of observations is 28. The group "all countries" already excludes Egypt and Taiwan. In the second regression, we exclude the additional outliers, Israel and Japan, their relative positions in the sample presented in Graphs 5.1 and 5.2. Both regressions include constants which are not shown for brevity.
***significant at the 1% level.

We observe that countries with comparatively large positive short-run and long-run coefficients are mostly emerging market economies. The exceptions to this are Japan and New Zealand. We focus a little more in depth on the ten countries with the largest positive coefficients[64] and support our discussion by also considering the effects of intervention on the individual components of base money – currency, and required reserves/deposit accounts with the central bank, for these countries. The associated regression results[65] are presented in Table 5.4.

In the case of Japan, the statistically and economically significant short-run and long-run coefficients (for deposit accounts with the Bank of Japan) would appear to be consistent with its policy of base money expansion. Nevertheless, clarifications on the interpretation of these coefficients are required.

In Japan, it is the Ministry of Finance that determines intervention policy and issues securities known as Financing Bills to raise funds prior to intervention operations which are conducted by the Bank of Japan. Thus, in one sense intervention is automatically sterilised. However, the Bank of Japan may still respond to the new liquidity created (Fatum and Hutchison, 2005). Using daily data on current account balances with the Bank of Japan and intervention operations for the period 2003-2004, during which the Bank of Japan had intervened heavily, the authors find that intervention does not explain changes in the current account balances. Defining complete sterilisation as being consistent with a lack of response of current account balances to intervention, it would seem that was a high degree of sterilisation at least on a daily frequency. They nevertheless note that these two variables may be highly correlated at lower frequencies, namely at monthly and quarterly intervals.

As such, the results that we observe in our analysis of Japan may not reflect an active non-sterilisation policy but rather the independent pursuit of base money expansion in order to stimulate the Japanese economy. It should also be noted that our results are based on a regression which includes an impulse dummy variable for 2004q1, when the sharpest increase in intervention was observed and which represents an outlier in the data. Excluding this dummy variable the short-run and long-run coefficients are lower at 0.247 and 0.360 respectively, and statistically insignificant. However, as presented later in the section on robustness analysis, the

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64 The countries are Argentina, China, Colombia, Hong Kong, India, Israel, Japan, New Zealand, Peru and Russia.

65 The specifications follow equation 5.1 but instead of growth in base money as the dependent variable, we use the change in currency and required reserves/deposit accounts respectively, both of which are scaled by the level of base money lagged one period.

effects were nevertheless economically and statistically significant for the sample period 1990q2 - 2000q4.

New Zealand also presents a unique case as it had introduced a new liquidity management framework in July 2006. The new framework involved increasing the level of settlement cash balances in the money market in stages with injections of cash made primarily through foreign exchange swaps (Reserve Bank of New Zealand, 2006). This entailed increases in the central bank's foreign reserves and correspondingly in banks' cash balances which can account for the positive long-run effect on deposit accounts with the central bank that we observe.[66]

For Hong Kong, as expected the short-run and long-run effects on deposit accounts with the monetary authority are positive and significant given its currency board regime[67]. With regard to Israel, which has the largest positive short-run and long-run coefficients in our sample, this reflects that when large intervention operations take place the main sterilisation method is for commercial banks to place deposits in interest earning accounts with the central bank, through monetary deposit auctions. Sokoler (2005) makes note of this method of sterilisation of intervention operations by the Bank of Israel during a period of substantial intervention in the second half of the 1990s. The same method of sterilisation was also employed when the Bank of Israel embarked on another round of steadily increasing intervention beginning March 2008 (Bank of Israel, 2009).[68]

Among the three Latin American countries, Argentina, Colombia and Peru, there are different underlying factors that account for the effects of intervention on base money. All three have actively used reserve requirements although not necessarily always in the context of intervention (see Gray (2011), and Montoro and Moreno (2011) for a snapshot of reserve requirement ratios across countries). However, as presented in Table 5.4, the effect of intervention is mainly seen on currency in the case of Argentina and Peru. For Argentina, the effect on currency is

[66] Strictly speaking, we would expect this to be also reflected as a contemporaneous effect and the data suggests that the increases in foreign reserves and base money occurred in the same period at least for two quarters. However, the short-run coefficient is economically and statistically insignificant.

[67] It should be noted that the coefficients are not as high as some of the other countries despite the unique monetary policy framework because we have excluded the outstanding amount of EFBNs from the base money measure. See footnote 57 for further details.

[68] Intervention operations were carried out to build foreign exchange reserves and therefore, financial resilience. Amidst the global slowdown, it also served to avoid excessive exchange rate appreciation which could have had adverse effects on Israel's exports.

consistent with increased demand for cash holdings after the collapse of the currency board system in 2002. On the other hand, with regard to Colombia, the effect of intervention on required reserves/deposit accounts is statistically significant.[69]

With regard to Russia, the effect of intervention is statistically significant on currency rather than required reserves/deposit accounts but the latter is of a non-trivial economic size and fairly close to being statistically significant. The two large Asian economies, China and India provide contrasting information. With respect to India, the change in base money associated with intervention is mainly emanating from required reserves. The results for China are rather peculiar. It should be highlighted that the coefficients for the effect of intervention on base money (as reported in Table 5.1) are statistically insignificant if based on default standard errors[70]. If we take the results as such, then there appears to be consistency with the results of intervention effects on currency and required reserves/deposit accounts, which are negative and statistically insignificant respectively. It is interesting to note that despite accumulating the largest absolute amount of reserves among all the countries in our sample, and with obvious growth in reserves and base money, once control factors are taken into account, intervention does not appear to have an effect on base money in China.[71]

Our results thus far are broadly consistent with those of other studies in that the coefficients for the effects of intervention on changes in base money average a low value. This is comparable to the results of high sterilisation coefficients of the other studies which use ΔNDA as the dependent variable. However, the issues of differences between countries, and variations over time for individual countries and across regions are to some extent misrepresented by Aizenman and Glick (2009) and Cardarelli *et al.* (2009) given that the effects of different monetary policy frameworks and the use of reserve requirements are not considered as possible factors for these variations. This is something we have sought to highlight in our

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[69] In the late 2000s, the Central Bank of Colombia begin using interest bearing deposits as a monetary contraction tool, in line with offsetting intervention to keep short-term interest rates at levels consistent with its inflation target. Source: www.banrep.gov.co/press _release/press.htm.

[70] The t-statistics corresponding to the default standard errors are 1.491 and 0.099 respectively for the short-run and long-run coefficients.

[71] The lack of effect is consistent with other studies which report a high degree of sterilisation (see *Appendix 1*). We also note that while reserve requirement ratios were on an increasing trend over 2006q4-2008q3, these actions may not have been in a direct one-to-one response to increases in intervention. At the same time, there were active issuances of central bank securities which made the offsetting elements within ΔNDA particularly sizable. The net effect of these: base money expanded much less than foreign exchange reserves.

analysis. We have drawn attention to the relative effects of intervention on changes in currency and changes in required reserves/deposit accounts for a subset of countries. Even if the effects are higher for some countries than others, particularly if seen in terms of currency in circulation or the non-active use of required reserves/deposit accounts, these cannot be viewed in isolation from the money multiplier and importantly, broad money expansion.

For our subset of countries, we find that money multipliers are lower or on a downward trend in the 2000s for Argentina, Peru and Colombia, as well as for Japan. As expected there are volatile movements for Hong Kong, Israel and New Zealand, given similar volatile movements in base money due to the special factors that we highlighted earlier. China, India and Russia exhibit slight upward trends, with minor troughs for China and India, and a visible increase for Russia, in the late 2000s owing to changes in reserve requirement ratios. Graphs of money multipliers for all countries in our sample are provided in *Appendix 4: Broad Money Multipliers*. The various average values, trends and degrees of volatility observed are indicative of disconnect between changes in base money and broad money developments.[72]

In the next section, we test for differences among the countries in our sample by categorising them into groups based on regions, income levels, balance of payments positions, intervention indicators, exchange rate flexibility, and monetary policy frameworks.

[72] Disyatat (2011) argues that the money multiplier is not a meaningful concept in the context of an interest rate-targeting framework. This is because the target for the interest rate can be met without changes to bank reserves. As such there is no direct link between bank reserves with monetary policy and bank lending.

Table 5.4: Real Intervention Effects on Changes in Real Currency in Circulation (ΔReal CIC) and Real Required Reserves/Deposit Accounts (ΔReal RR) – Selected Country Results

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real CIC}_t/\text{Real RM}_{res,t-1}$ Short-run	Long-run	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RR}_t/\text{Real RM}_{res,t-1}$ Short-run	Long-run
Argentina	0.163***	0.141***	-0.017	-0.018
	{8.700}	{66.146}	(-0.470)	(0.224)
	1995q2-2010q2		1994q4-2010q2	
China	-0.005	-0.113***	0.014	0.066
	(-0.157)	(13.210)	(0.126)	(0.071)
	1991q2-2010q2		1991q2-2010q2	
Colombia	-0.012	0.100	0.008	0.096***
	[-0.430]	[0.846]	[0.129]	[15.277]
	1995q1-2010q2		1995q1-2010q2	
Hong Kong	0.039***	0.012	0.285***	0.395***
	(2.818)	(0.045)	(5.577)	(23.545)
	1999q4-2010q2		1994q4-2010q2	
India	-0.013	-0.897	0.140**	0.209***
	(-0.570)	(0.044)	(2.346)	(17.469)
	1997q3-2010q2		1996q4-2010q2	
Israel	0.025*	0.025*	0.578***	0.593***
	{1.842}	{3.392}	{5.677}	{18.008}
	1990q3-2010q2		1990q4-2010q2	
Japan	-0.027	-0.067	0.237**	0.355**
	[-0.612]	[0.389]	[2.232]	[5.193]
	1991q2-2010q2		1990q2-2010q2	
New Zealand	0.001	-0.006*	0.051	0.285**
	(0.181)	(3.255)	[1.375]	[4.349]
	1991q1-2010q2		1991q2-2010q2	
Peru	0.027***	0.062***	0.009	0.015***
	(2.972)	(13.896)	[1.421]	[14.335]
	1996q3-2010q2		1996q3-2010q2	
Russia	0.178***	0.074*	0.071	0.098
	(8.252)	(3.204)	[1.199]	[2.676]
	1996q3-2010q2		1996q3-2010q2	

- The respective specifications used follow equation 5.1 with $\Delta\text{Real CIC}_t/\text{Real RM}_{res,t-1}$ and $\Delta\text{Real RR}_t/\text{Real RM}_{res,t-1}$ as the dependent variables.
- For the short-run coefficients, t-statistics are reported in brackets. For the long-run coefficients F-statistics are reported in brackets.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$which is not removed in the general to specific modelling process.

5.2.2 Tests for the Relevance of Differences in Country Characteristics

As presented in Chapter 4 and at the start of this chapter, our hypothesis is that there would only be significant differences in the coefficients for the effects of real intervention on changes in real base money if reserve requirements are an important policy tool used in response to intervention operations; or if the monetary policy framework in operation is that of a currency board or involves the deliberate and continuous expansion of the monetary base. The use of reserve requirements may be more apparent when countries experience sustained balance of payments inflows, that is the effects of surpluses and deficits may be distinct from the effects of trade and capital account openness.

While income levels are related to financial development and influence the demand for currency holdings, it may be incorrect to deduce that lower income countries would experience higher effects of intervention on currency especially once control factors have been taken into account. Higher income countries, with greater current account and capital account openness may in fact experience higher intervention effects on base money, since these could reflect the stronger influence of financial factors compared to real sector factors.

5.2.2.1 Equality Tests for Differences in Coefficients on Real Intervention Effects between Groups of Countries

In Table 5.5, we categorise the countries in our sample according to regions, current account and capital account balances (surpluses versus deficits), income levels (high income versus middle income) and monetary policy frameworks (inflation-targeting versus non-inflation-targeting) and present the results of mean and median equality tests for differences in the coefficients on real intervention effects[73]. We find that the only significant difference between groups arises when we compare inflation-targeting countries against non-inflation-targeting countries. The statistically significant difference applies to both the short-run and long-run coefficients, more so in the former case, with non-inflation-targeting countries

[73] In pre-testing for normality and homogenous variances across the subgroups, the respective distributions for the short-run and long-run coefficients were found to exhibit non-normality. As such while we report both, the ANOVA F-test statistic for mean equality and the Mann-Whitney/Kruskal-Wallis test statistic for median equality, more emphasis should be placed on the latter since these are robust to outliers.

displaying higher average and median coefficients. While we have not reported the results in Table 5.5, we find that once we exclude Hong Kong and Japan from the non-inflation-targeting group, the statistical significance of the difference between the two groups is reduced[74]. Thus, the difference between the inflation-targeting and non-inflation-targeting countries has to be assessed with recognition of the unique monetary policy frameworks in these two countries. Furthermore, as analysed earlier on, with regard to Argentina and India, exceptional factors may also be at play – remonetisation in the former, and the use of required reserves in the latter. IMF (2011), in their analysis of sterilisation in Asian countries, conclude based on panel data analysis that large and persistent capital inflows pose a challenge particularly for non-inflation-targeting countries, which exhibit lower sterilisation. However, in their group of five non-inflation-targeting countries, they do not make note of the uniqueness that pertains to Hong Kong, which by nature of its framework will indeed sterilise less.

[74] The Mann-Whitney test statistics are 1.792 (significant at the 10% level) and 1.185 (not statistically significant) for the short-run and long-run coefficients respectively.

<u>Table 5.5</u>: Equality Tests for Real Intervention Effects on Real Base Money Change

Groups	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			
	Short-run Coefficient		**Long-run Coefficient**	
	Group Mean [Median]	**Equality Test Statistic – Mean [Median]**	**Group Mean [Median]**	**Equality Test Statistic – Mean [Median]**
1. **Region**				
Asia	0.045* [0.030]	0.633	0.030*** [0.039]	1.001
Latin America	0.037* [0.028]	[1.493]	0.101*** [0.091]	[3.063]
Other EMEs	0.138* [0.057]		0.181*** [0.090]	
Developed Economies	0.084 [0.031]		0.163** [0.022]	
2. **Current Account (CA) Balance**				
CA surplus	0.090* [0.034]	0.242	0.095** [0.039]	0.193
CA deficit	0.062* [0.030]	[0.484]	0.125***[0.084]	[0.622]
3. **Capital Account (KA) Balance**				
KA surplus	0.059* [0.030]	0.823	0.103***[0.062]	0.147
KA deficit	0.116 [0.040]	[0.534]	0.132** [0.051]	[0.254]
4. **Income Level**				
High income	0.104 [0.034]	0.912	0.158** [0.048]	1.392
Middle income	0.050* [0.030]	[0.369]	0.070***[0.054]	[0.783]
5. **Monetary Policy Framework**				
Inflation-targeting	0.035 [0.027]	4.597**	0.081***[0.024]	1.522
Non-inflation-targeting	0.158** [0.157]	[2.361]**	0.174***[0.152]	[1.746]*

The mean equality test is the single factor ANOVA F-test and the median equality test is either the Mann-Whitney test (two subgroups) or the Kruskal-Wallis test (more than two subgroups).
CA and KA surpluses are measured based on the number of surplus years as a proportion of the total number of years corresponding to the regression sample period for each country. A country is recorded as a surplus country if the proportion exceeds 0.5.
Income level is measured by the average of GDP per capita based on purchasing power parity over the regression sample period for each country. Countries are classified as either high or middle income based on the World Bank income classification scheme.
Inflation-targeting countries are countries that have adopted the inflation-targeting framework at some point during our sample period.
All groups exclude Egypt and Taiwan.
The statistical significances of the subgroup averages of short-run and long-run coefficients in the "Group Mean [Median]" columns are based on the corresponding averages of individual country t-and F-statistics. These do not indicate statistically significant differences across the subgroups.
***significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

5.2.2.2 *Equality Tests for Differences in Country Characteristics based on Differences in Real Intervention Effects*

In Tables 5.6(a) and 5.6(b), we carry out further analysis by way of mean and median[75] equality tests across characteristics of countries grouped by the boxplot quartiles for the short-run and long-run real intervention effects on changes in real base money as seen in Graph 5.1[76]. As in Table 5.5 in the previous subsection, the characteristics include the surplus years on current account and capital account balances, and income levels. We also include additional characteristics, namely current account and capital account openness; the balance positions for subcomponents of the capital account – the sum of net direct investment and portfolio investment, and net other investment balances respectively; intervention indicators – volatility, reserve accumulation, and the number of surplus periods[77]; and exchange rate flexibility. For the current account and capital account balances (including for the subcomponents), aside from the number of surplus years, we also consider the average balance over the regression sample period of each country, scaled by the average annual nominal GDP. We do this to provide an element of scale for the surpluses (or deficits) and in relation to economy size. The net other investment balances excludes official flows. We draw attention to this subcomponent of the capital account to assess if there is a link between flows related to bank loans and deposits, and the effects of real intervention on changes in real base money. Details of the measurement of each characteristic are provided in the notes to the tables.

Essentially, we focus on three elements not explored in Table 5.5: (i) the nature of intervention – the amount of intervention as captured by its volatility, and the tendency for sustained one-way intervention as reflected by surplus quarters and reserve accumulation; (ii) the role of balance of payments surpluses and deficits reflected in net balances versus the size of gross external flows as captured by the

[75] The ANOVA F-test is used when the characteristic under investigation exhibits normality and homogenous variances, the Welch F-test if it exhibits normality but heterogeneous variances, and the Kruskal-Wallis test for median equality if there is non-normality.

[76] The number of countries in each quartile, beginning with the upper quartile is as follows: 7, 15, and 6 respectively for the short-run coefficients; and 8, 13 and 7 respectively for the long-run coefficients.

[77] Surplus periods refer to the number of quarters over the regression sample period, during which intervention was of a positive value, leading to reserves accumulation (exchange rate appreciation pressure) as opposed to reserves depletion (exchange rate depreciation pressure).

openness variables; and (iii) exchange rate flexibility which reflects the confluence of a country's exchange rate framework, balance of payments shocks and intervention activity.

For the different quartile groups of both, short-run and long-run coefficients, we observe statistically significant differences in capital account openness. It tentatively suggests that countries with higher capital account openness tend to have higher coefficients on real intervention effects. However, the median values are not monotonic in that it is the inter-quartile group rather than the upper quartile group that has the highest median value for capital account openness. A more thorough analysis indicates that the difference in medians is between the inter-quartile and lower quartile groups rather than between the upper quartile and lower quartile groups. The significance of capital account openness over net balances in the balance of payments subaccounts somewhat contradicts our initial hypothesis about the importance of the accumulation of flows but nevertheless points to the importance of the size and volatility in gross capital flows.

We also find some evidence of statistically significant differences in a few other characteristics – surplus quarters of intervention in the case of the short-run coefficients; and surplus years of net direct investment and portfolio balance, intervention volatility and income levels in the case of the long-run coefficients. Only in the second case is there a monotonic ordering of the medians of the characteristic. We view these results with caution. One possible criticism of our approach in Tables 5.6(a) and 5.6(b) is the lack of clear delineation between the groups of coefficients, even though it is based on the sample dispersion, since the absolute values of the coefficients are quite small. As a test of the sensitivity of the results to changes in groupings, we also grouped the coefficients as follows: >0.100, >0 but <0.100, and <0[78], which shifts a few countries at the margins of the boxplot quartiles into different subgroups. The results of analysis with these groupings indicate that whilst the statistical significance of differences in capital account openness remains, the statistical significances of the other differences disappear (see Tables 5(c) and 5(d)). The differences in terms of current account openness also turn

[78] The number of countries in each subgroup is as follows: 8, 11 and 9 respectively for the short-run coefficients; and 10, 9 and 9 respectively for the long-run coefficients.

statistically significant when we utilise the groupings based on the size and sign of the coefficients. Mirroring capital account openness, the median values among the subgroups are not monotonically ordered. There is also a statistically significant difference in intervention volatility for the short-run coefficients, with the lowest median of volatility associated with the smallest coefficients.

While variations between groups may not be particularly apparent, our analysis here does not provide information on possible linear relationships. Next, in subsection 5.2.2.3 we discuss the results of simple bivariate regressions between the coefficients on real intervention effects on changes in real base money and specific country characteristics.

<u>Table 5.6(a)</u>: Equality Tests of Country Characteristics Grouped by Boxplot Quartiles of Short-run Intervention Effects on Base Money Change

	Country Characteristic	Subgroup Average/[Median] of Characteristic			Equality Test Statistic
		Upper quartile	Inter-quartile	Lower quartile	
1.	Openness				
	Current account	[0.586]	[0.807]	[0.718]	1.729
	Capital account	[0.121]	[0.168]	[0.094]	4.912*
2.	Current Account Balance				
	Surplus years	0.675	0.367	0.542	1.930
	Average balance	[2.851]	[-1.831]	[0.657]	3.550
3.	Capital Account Balance				
	Surplus years	0.569	0.723	0.646	0.623
	Average balance	[1.388]	[3.540]	[1.371]	2.135
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years	0.605	0.757	0.798	0.940
	Average balance	[0.183]	[2.562]	[1.841]	2.756
5.	Net Other Investment Balance				
	Surplus years	0.523	0.497	0.435	0.265
	Average balance	[-0.044]	[0.353]	[0.018]	0.486
6.	Intervention Indicators				
	Volatility	0.907	0.839	0.549	2.074
	Reserve accumulation	[0.444]	[0.187]	[0.245]	2.731
	Surplus quarters	0.719	0.605	0.655	2.981*
7.	Income Level	14.986	17.153	11.967	0.480
8.	Exchange Rate Flexibility	8.030	9.965	9.413	0.307
Note:					
Corresponding subgroup average of short-run real intervention effects		0.283***	0.032	-0.062*	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the boxplot quartiles of real intervention effects in Graph 5.1.
The mean equality test is either the single-factor ANOVA F-test or the Welch F-test for unequal variances.
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

Table 5.6(b): Equality Tests of Country Characteristics Grouped by Boxplot Quartiles of Long-run Intervention Effects on Base Money Change

	Country Characteristic	Subgroup Average/[Median] of Characteristic: Upper quartile	Inter-quartile	Lower quartile	Equality Test Statistic
1.	Openness				
	Current account	[0.544]	[0.828]	[0.642]	3.366
	Capital account	[0.142]	[0.201]	[0.094]	8.266**
2.	Current Account Balance				
	Surplus years	0.538	0.473	0.432	0.153
	Average balance	[-0.257]	[-0.078]	[0.116]	0.101
3.	Capital Account Balance				
	Surplus years	0.604	0.679	0.722	0.325
	Average balance	[0.764]	[2.067]	[2.496]	0.440
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years[#]	0.616	0.712	0.883	3.629*
	Average balance	[1.018]	[2.562]	[2.421]	1.690
5.	Net Other Investment Balance				
	Surplus years	0.499	0.496	0.469	0.043
	Average balance	[0.133]	[0.353]	[-0.428]	0.701
6.	Intervention Indicators				
	Volatility[#]	0.834	0.911	0.532	2.806*
	Reserve accumulation	[0.270]	[0.250]	[0.192]	0.026
	Surplus quarters	0.646	0.625	0.677	0.496
7.	Income Level[#]	16.600	18.670	8.357	4.226**
8.	Exchange Rate Flexibility	8.513	9.381	10.302	1.108
Note:					
Corresponding subgroup average of long-run real intervention effects		0.343***	0.057***	-0.053*	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the boxplot quartiles of real intervention effects in Graph 5.1.
The mean equality test is either the single-factor ANOVA F-test or the Welch F-test for unequal variances.
([#]The mean equality test statistic is from the Welch F-test. The ANOVA F-test statistic is not statistically significant.)
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

Table 5.6(c): Equality Tests of Country Characteristics Grouped by Coefficient Sizes of Short-run Intervention Effects on Base Money Change

	Country Characteristic	Subgroup Average/[Median] of Characteristic For Intervention Effects: >0.100	<0.100, >0	<0	Equality Test Statistic
1.	Openness				
	Current account	[0.518]	[0.885]	[0.642]	5.751*
	Capital account	[0.117]	[0.169]	[0.113]	5.368*
2.	Current Account Balance				
	Surplus years	0.657	0.441	0.375	1.419
	Average balance	[1.400]	[-0.078]	[-1.294]	2.094
3.	Capital Account Balance				
	Surplus years	0.579	0.666	0.750	0.670
	Average balance	[0.764]	[2.496]	[2.640]	1.773
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years	0.623	0.715	0.837	1.281
	Average balance	[1.018]	[2.562]	[2.421]	2.299
5.	Net Other Investment Balance				
	Surplus years	0.473	0.474	0.526	0.171
	Average balance	[-0.081]	[0.353]	[0.464]	0.375
6.	Intervention Indicators				
	Volatility#	0.861	0.953	0.540	3.038*
	Reserve accumulation	[0.386]	[0.250]	[0.187]	[1.847
	Surplus quarters	0.648	0.656	0.625	0.188
7.	Income Level	14.425	17.773	13.678	0.388
8.	Exchange Rate Flexibility	7.769	9.707	10.360	0.124
Note:					
Corresponding subgroup average of short-run real intervention effects		0.262***	0.037	-0.045	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the relative sizes of real intervention effects on real base money change (>0.100, <0.100 but >0, and <0).
The mean equality test is either the single-factor ANOVA F-test or the Welch F-test for unequal variances.
(#The mean equality test statistic is from the Welch F-test. The ANOVA F-test statistic is not statistically significant.)
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

Table 5.6(d): Equality Tests of Country Characteristics Grouped by Coefficient Sizes of Long-run Intervention Effects on Base Money Change

Country Characteristic		Subgroup Average/[Median] of Characteristic For Intervention Effects: >0.100	<0.100, >0	<0	Equality Test Statistic
1.	Openness				
	Current account	[0.570]	[0.885]	[0.642]	4.838*
	Capital account	[0.127]	[0.201]	[0.113]	5.318*
2.	Current Account Balance				
	Surplus years	0.462	0.544	0.442	0.188
	Average balance	[-0.681]	[-0.064]	[0.116]	0.592
3.	Capital Account Balance				
	Surplus years	0.683	0.602	0.717	0.329
	Average balance	[2.345]	[1.315]	[2.496]	0.517
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years#	0.686	0.663	0.839	1.493
	Average balance	[2.108]	[0.656]	[2.421]	0.530
5.	Net Other Investment Balance				
	Surplus years	0.531	0.442	0.493	0.384
	Average balance	[0.557]	[-0.031]	[0.158]	0.833
6.	Intervention Indicators				
	Volatility#	0.818	0.995	0.567	2.254
	Reserve accumulation	[0.268]	[0.250]	[0.192]	0.664
	Surplus quarters	0.646	0.652	0.634	0.058
7.	Income Level	15.240	18.456	12.833	0.589
8.	Exchange Rate Flexibility	8.761	9.360	10.034	0.503
Note:					
Corresponding subgroup average of long-run real intervention effects		0.297***	0.058**	-0.043	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the relative sizes of real intervention effects on real base money change (>0.100, <0.100 but >0, and <0).
The mean equality test is either the single-factor ANOVA F-test or the Welch F-test for unequal variances.
(#The mean equality test statistic is from the Welch F-test. The ANOVA F-test statistic is not statistically significant.)
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

5.2.2.3 Regression Analysis between Coefficients on Real Intervention Effects and Country Characteristics

In this subsection, we assess if there exist linear relationships between real intervention effects on changes in real base money and country characteristics. We treat the estimated coefficients for real intervention effects in the real base money equation for each country as the dependent variable and investigate if these coefficients vary systematically with income levels; the nature of intervention (volatility, the number of surplus periods, and reserve accumulation); exchange rate flexibility; and the nature of the current and capital accounts in terms of openness and net balances. The bivariate regression specification is as follows:

$$y_i = \alpha + \beta x_i \tag{5.3}$$

where
i =country
y= short-run/long- run coefficient on real intervention effect
x= country characteristic

The characteristics are the same as those that were used in the equality tests in subsection 5.2.2.2. The choice of characteristics reflects our interest in investigating if the coefficients on real intervention effects are positively related to the amount of intervention and size of gross external flows; and whether there is a distinction between prolonged surpluses and deficits. Large and volatile capital inflows and persistent one-way intervention may induce higher coefficients by way of the increased use of reserve requirements. Meanwhile, we expect that there might be a negative relationship between the coefficients with exchange rate flexibility to the extent that it is closely tied with intervention and captures the operating procedure of non-sterilisation that may be associated with hard peg regimes.

Before we discuss the results of the regression analysis, in Table 5.7, we present unconditional correlation coefficients between the coefficients on real intervention effects and the majority of the country characteristics, as well as between the characteristics themselves. The description of the measurement of each characteristic is provided in the notes to the table.

Among the characteristics of the countries in our sample, current account and capital account openness are strongly positively correlated with one another and with intervention volatility and reserve accumulation (but not with intervention surplus periods, which does not capture scale effects, neither of intervention nor of the economy). However, it is the current account balance, rather than the capital account balance, that is *positively* correlated with openness, intervention volatility, surplus periods and reserve accumulation. The current account balance is also marginally positively correlated with per capita income. Exchange rate flexibility meanwhile, is to some extent, negatively correlated with intervention volatility and reserve accumulation.

Turning to the correlations between the coefficients on real intervention effects and the various characteristics as listed in Table 5.7, we find no statistically significant relationships.[79] The highest correlations and associated t-statistics, relatively, are the positive correlation between the short-run coefficient and surplus periods, and the negative correlation between the short-run coefficient and exchange rate flexibility.

[79] Upon consideration of the surplus years for the current account, capital account, net direct and portfolio investment balances and other investment balances; as well as the average balances for the latter two variables, we find statistically significant negative correlations between the number of surplus years in the net direct and portfolio investment balances with the coefficients on real intervention effects (-0.457 and -0.331 for the short-run and long-run coefficients respectively).

<u>Table 5.7:</u> Correlation Coefficients (with t-statistics) for Real Intervention Effects on Real Base Money Change and Selected Country Characteristics

	Short-run coefficient (SR)	LR	Y/c	FXIV	FXIS	RA	ERF	CAO	KAO	CAB
Long-run coefficient (LR)	0.904*** (10.788)									
GDP per capita (Y/c)	0.189 (0.984)	0.148 (0.765)								
Intervention volatility (FXIV)	0.128 (0.659)	-0.030 (-0.155)	0.294 (1.569)							
Proportion of time with positive Intervention (FXIS)	0.207 (1.079)	0.093 (0.477)	-0.128 (-0.657)	0.229 (1.200)						
Reserve accumulation (RA)	0.160 (0.828)	-0.043 (-0.218)	0.073 (0.374)	0.702*** (5.019)	0.706*** (5.086)					
Exchange rate flexibility (ERF)	-0.224 (-1.169)	0.004 (0.018)	0.013 (0.068)	-0.445** (-2.535)	-0.084 (-0.432)	-0.396** (-2.199)				
Current account openness (CAO)	0.048 (0.247)	-0.100 (-0.514)	0.476*** (2.758)	0.742*** (5.637)	0.252 (1.330)	0.680*** (4.729)	-0.418** (-2.348)			
Capital account openness (KAO)	0.163 (0.843)	-0.012 (-0.060)	0.617*** (3.997)	0.680*** (4.730)	0.077 (0.394)	0.462*** (2.656)	-0.421** (-2.370)	0.874*** (9.153)		
Current account balance (CAB)	0.152 (0.783)	-0.039 (-0.201)	0.402** (2.239)	0.685*** (4.795)	0.436** (2.473)	0.704*** (5.055)	-0.253 (-1.336)	0.619*** (4.016)	0.512*** (3.038)	
Capital account balance (KAB)	-0.169 (-0.877)	-0.022 (-0.114)	-0.442** (-2.514)	-0.445** (-2.531)	-0.119 (-0.612)	-0.256 (-1.348)	0.138 (0.712)	-0.264 (-1.394)	-0.287 (-1.529)	-0.838*** (-7.833)

- Y/c is the measure of the annual average of GDP per capita based on purchasing power parity (millions of current international dollar) over the regression sample period.
- FXIV is measured by the standard deviation of the monthly changes in foreign exchange reserves (in US dollar), scaled by the average annual nominal GDP (in US dollar).
- FXIS is measured by the number of quarters with a positive increase in reserves as a proportion of the total number of quarters in the regression sample period. The values are between 0 and 1.
- RA is the sum of change in foreign exchange reserves (in US dollar) scaled by the average annual nominal GDP (in US dollar).
- ERF is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al*. (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.
- CAO and KAO are measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP. CA, KA and GDP are in nominal US dollars. The KA also includes net errors and omissions.
- CAB and KAB are measured as the average of the annual net position in each account scaled by the average annual GDP for the years that correspond to the regression sample period.
- ***significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

In Tables 5.8 and 5.9, we present the results of bivariate regressions between the short-run and long-run coefficients on real intervention effects and country characteristics. Plots of the coefficients against these characteristics are presented in Graphs 5.3 and 5.4.

We find that both, the short-run and long-run real intervention effects only have statistically significant relationships with the number of surplus years recorded for net direct and portfolio investment balances (DIPIS). The negative relationship is surprising, but on closer inspection of the plot of the two variables in question, we note that Israel and Japan, whose respective unique developments we have explored, have likely influenced the result. On the basis of the values of the t-statistics among other characteristics, we note that the short-run coefficient has relatively stronger links to the net direct and investment portfolio balance (DIPIB), current account surplus, exchange rate flexibility and surplus periods of intervention – negative relationships in the first and third instances, and positive relationship in the second and fourth cases. The t-statistics for links between the long-run coefficient and other characteristics are much weaker.

The analysis in this subsection highlights that while we see relationships between balance of payments flows with intervention volatility and reserve accumulation, the translation of these characteristics into particular effects of real intervention on changes in real base money is not so straight forward. Overall, we hardly see any connection between the characteristics and the coefficients for intervention effects. This is not unexpected given our discussion in earlier sections.

Table 5.8: Bivariate Regressions between Short-run Real Intervention Effects on Real Base Money Change and Country Characteristics

Country Characteristic (Regressor in bivariate regression)	Dependent Variable: Short-run Effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			
	Coefficient	**t-statistic**	**Adjusted R^2**	**Diagnostics**
1. GDP per capita (Y/c)	2.628	0.984	-0.00	Non-normality***
2. Intervention volatility (FXIV)	0.037	0.659	-0.02	Non-normality***
3. Surplus periods (FXIS)	0.282	1.079	0.01	Non-normality***
4. Reserve accumulation (RA)	0.062	0.828	-0.01	Non-normality***
5. Exchange rate flexibility (ERF)	-0.012	-1.169	0.01	Non-normality***
6. Current account openness (CAO)	0.007	0.247	-0.04	Non-normality***
7. Capital account openness (KAO)	0.091	0.843	-0.01	Non-normality***
8. Current account balance (CAB)	0.411	0.783	-0.01	Non-normality***
9. Current account surplus years (CAS)	0.108	1.385	0.03	Non-normality***
10. Capital account balance (KAB)	-0.665	-0.877	-0.01	Non-normality***
11. Capital account surplus years (KAS)	-0.123	-1.290	0.02	Non-normality***
12. Net direct and portfolio investment balance (DIPIB)	-1.046	-1.429	0.04	Non-normality***
13. Net direct and portfolio investment balance surplus years (DIPIS)	-0.246	-2.623**	0.18	Non-normality**
14. Net other investment balance (OIB)	0.338	0.476	-0.03	Non-normality***
15. Net other investment balance surplus years (OIS)	0.036	0.266	-0.04	Non-normality***

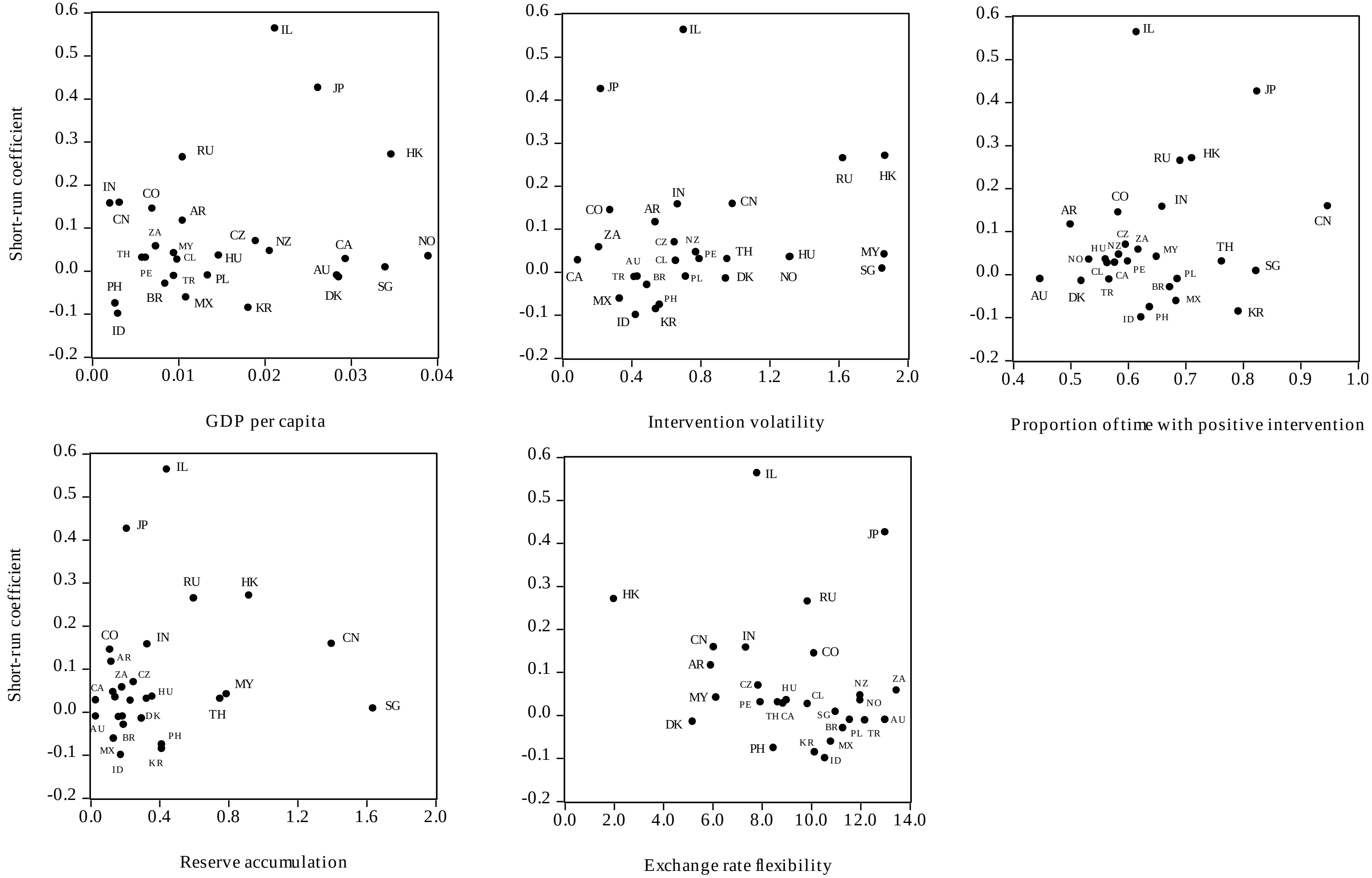
All regressions include a constant which is not shown for brevity.
For the t-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
See the notes to Tables 5.6(a)-(b) and Table 5.7 for descriptions of the respective regressors.

Table 5.9: Bivariate Regressions between Long-run Real Intervention Effects on Real Base Money Change and Country Characteristics

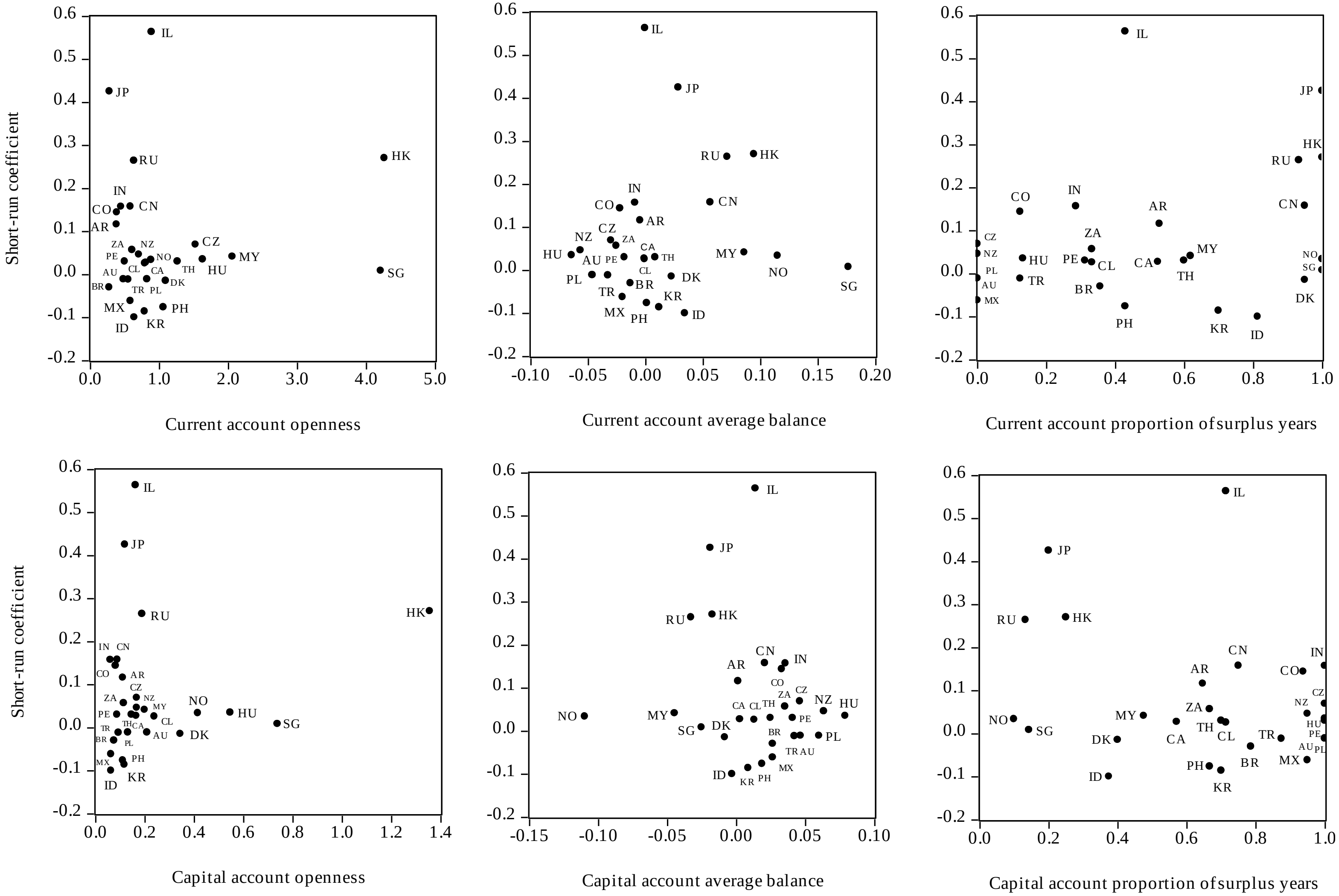
Country Characteristic (Regressor in bivariate regression)		Dependent Variable: Long-run Effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			
		Coefficient	t-statistic	Adjusted R^2	Diagnostics
1.	GDP per capita (Y/c)	2.620	0.765	-0.02	Non-normality***
2.	Intervention volatility (FXIV)	-0.011	-0.155	-0.04	Non-normality***
3.	Surplus periods (FXIS)	0.149	0.440	-0.03	Non-normality***
4.	Reserve accumulation (RA)	-0.021	-0.218	-0.04	Non-normality***
5.	Exchange rate flexibility (ERF)	0.000	0.018	-0.04	Non-normality***
6.	Current account openness (CAO)	-0.019	-0.514	-0.03	Non-normality***
7.	Capital account openness (KAO)	-0.008	-0.060	-0.04	Non-normality***
8.	Current account balance (CAB)	-0.136	-0.201	-0.04	Non-normality***
9.	Current account surplus years (CAS)	0.024	0.236	-0.04	Non-normality***
10.	Capital account balance (KAB)	-0.112	-0.114	-0.04	Non-normality***
11.	Capital account surplus years (KAS)	-0.053	-0.427	-0.03	Non-normality***
12.	Net direct and portfolio investment balance (DIPIB)	-0.464	-0.481	-0.03	Non-normality***
13.	Net direct and portfolio investment balance surplus years (DIPIS)	-0.226	-1.787*	0.08	Non-normality**
14.	Net other investment balance (OIB)	0.397	0.439	-0.03	Non-normality***
15.	Net other investment balance surplus years (OIS)	0.091	0.523	-0.03	Non-normality***

All regressions include a constant which is not shown for brevity.
For the t-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
See the notes to Tables 5.6(a)-(b) and Table 5.7 for descriptions of the respective regressors.

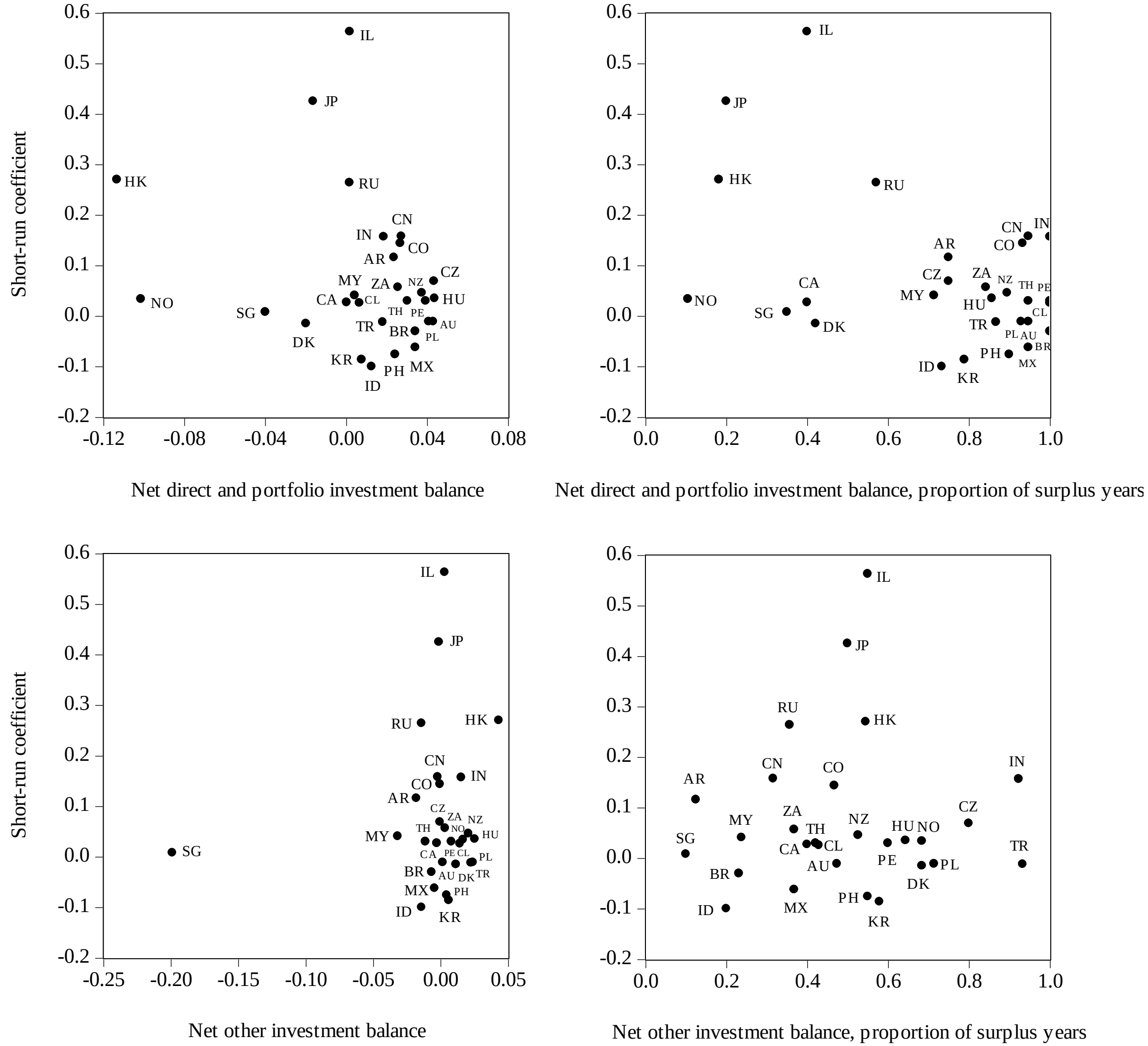
<u>Graph 5.3</u>: Short-run Real Intervention Effects on Real Base Money Change and Country Characteristics



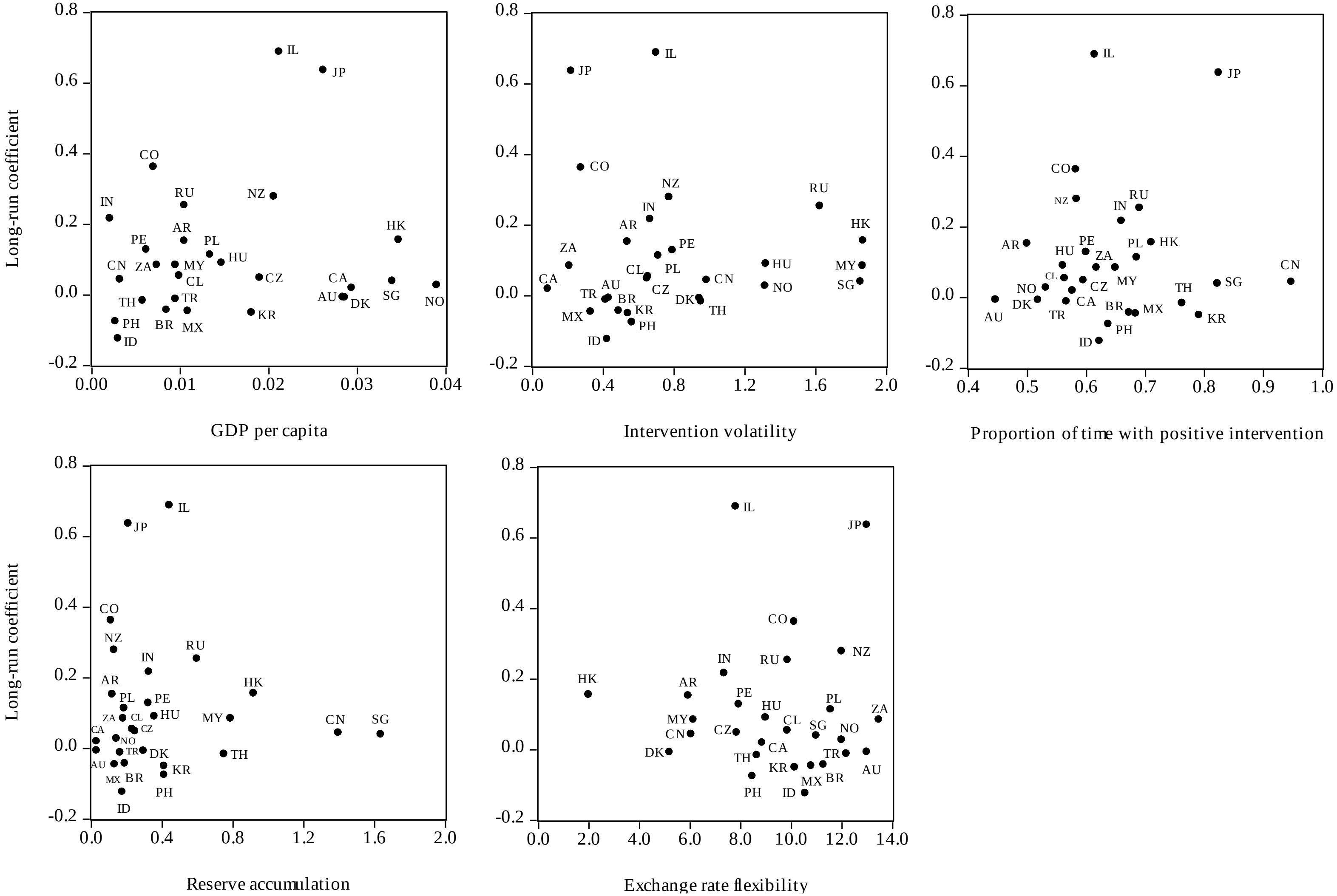
Graph 5.3: Continued



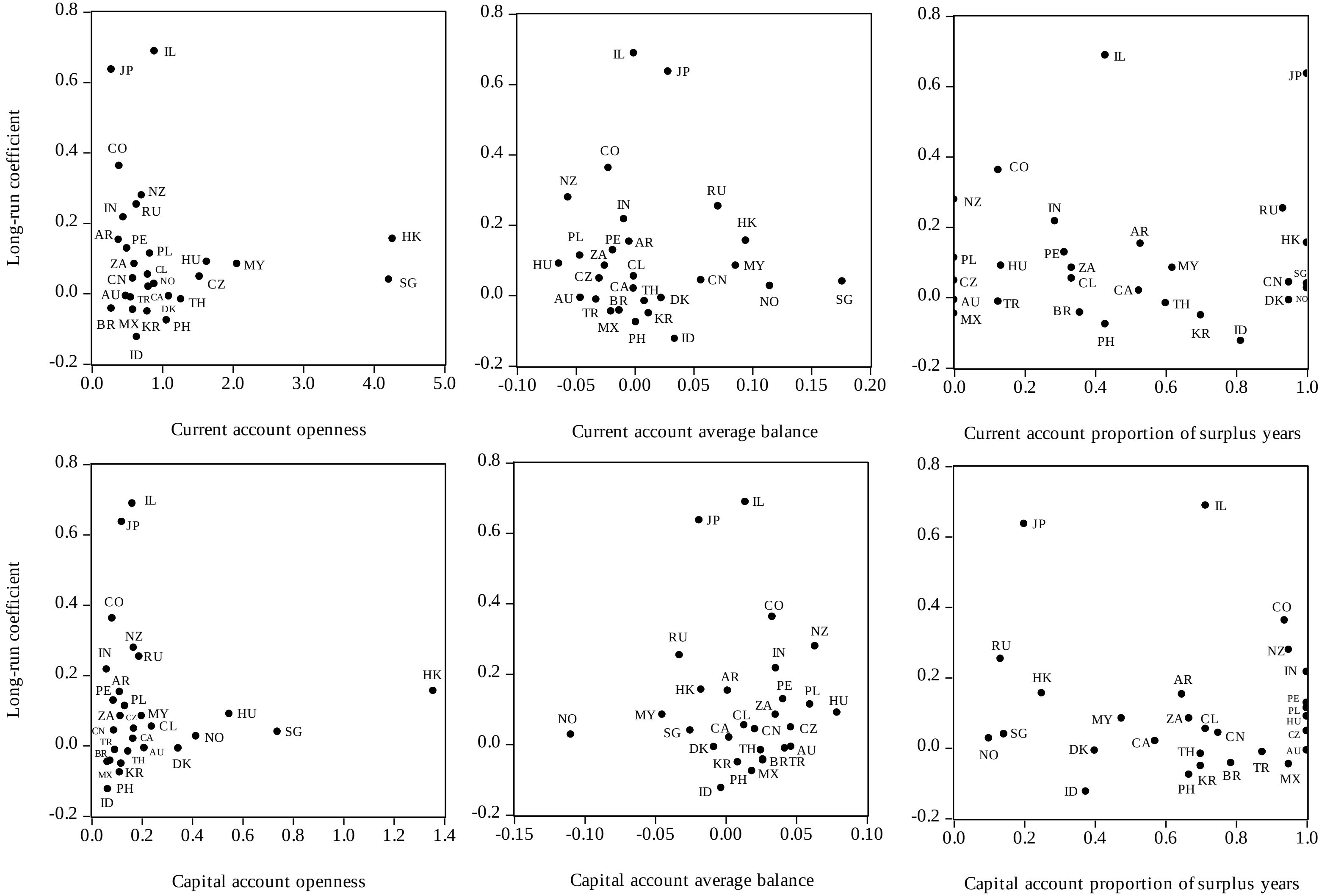
Graph 5.3: Continued



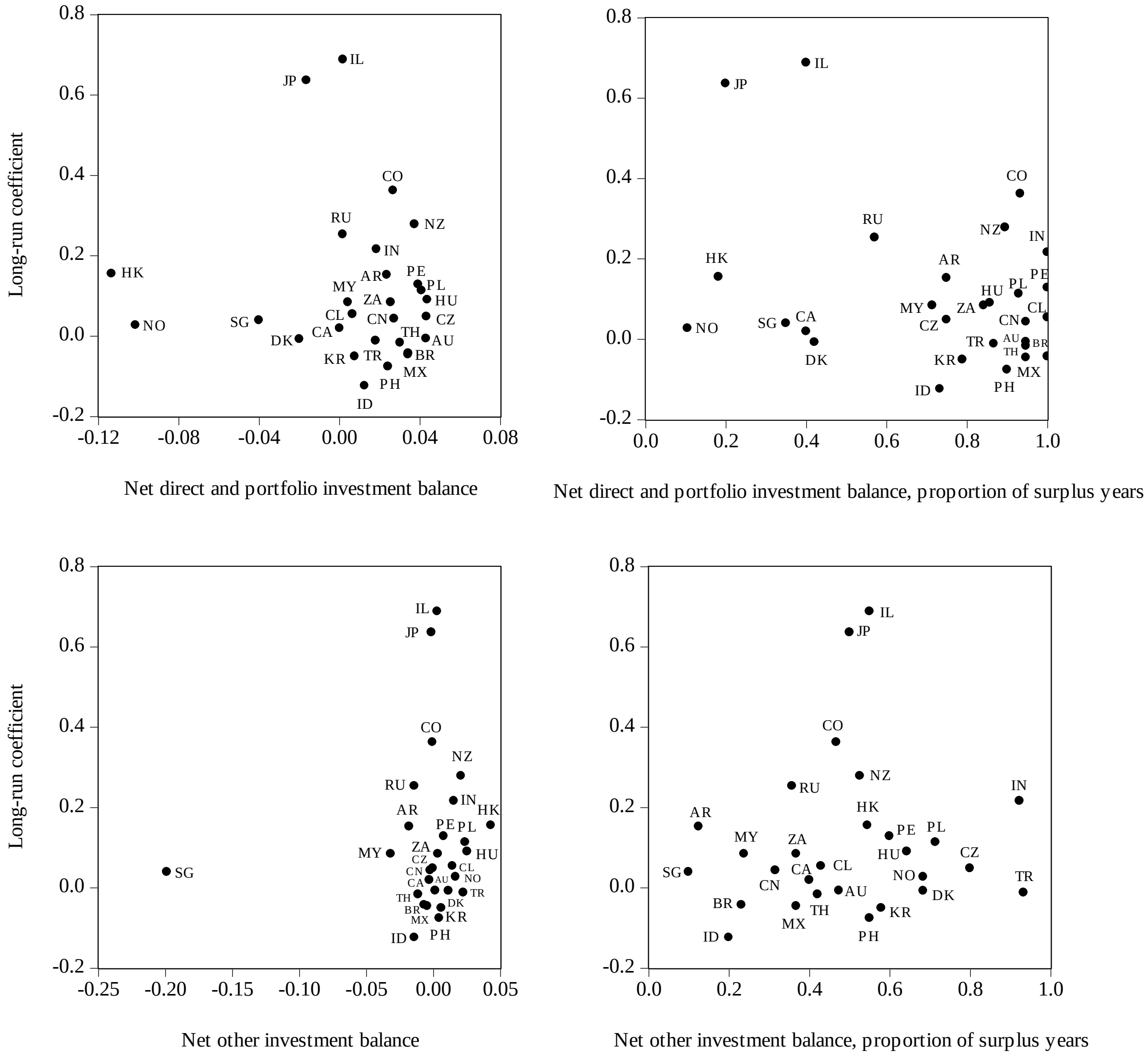
<u>Graph 5.4</u>: Long-run Real Intervention Effects on Real Base Money Change and Country Characteristics



Graph 5.4: Continued



<u>Graph 5.4</u>: Continued



5.2.3 Regression Diagnostics

In this section, we provide a summary assessment of individual country baseline regressions drawing on the results of diagnostic tests. The diagnostic tests mainly consist of those for serial correlation, heteroskedasticity and normality in the regression residuals; and regression misspecification (Ramsey's RESET). The issue of parameter stability is tackled in section 5.2.4.

The presence of lagged dependent variables as regressors in most of the parsimonious regressions means that the coefficients are biased but consistent if we appeal to large sample theory and if there is no serial correlation. To correct for the effects of serial correlation on the standard errors of coefficient estimates and allow for better statistical inferences, we have used Newey-West HAC standard errors for regressions where serial correlation has been detected in the unrestricted regression and/or in the final parsimonious regression based on both the Breusch-Godfrey LM statistic and the F-statistic for joint significance of lagged residuals. Where there are lagged dependent variables as regressors and serial correlation is still present in the final parsimonious regression, then it could be the case that our coefficient estimates are both biased and inconsistent.

In Table 5.10, we indicate with a tick if the final parsimonious change in real base money regression for each country has lagged dependent variables as regressors. We also indicate in the corresponding diagnostic tests columns if there was a rejection of the null hypothesis for specific tests and the associated level of statistical significance. If serial correlation, heteroskedasticity or non-normality was only detected in the unrestricted regression but not in the final parsimonious regression, we indicate as such.

There are seven countries that have lagged dependent variables as regressors in the presence of serial correlation in the final parsimonious specification – China, Colombia, the Czech Republic, Hungary, Poland, Australia and Japan. In most of these instances, statistical significance tests point to relatively weak serial correlation. In the case of Australia and New Zealand, strong non-normality remains despite the used of impulse dummy variables for several outliers. In the latter case, it is partly because of the introduction of the new liquidity framework, discussed earlier on, the effects of which we have chosen to keep intact. Meanwhile, the RESET suggests the omission of non-linear terms for Brazil, India and Malaysia. It is not clear what correction should be made to the functional form but we can deduce that the non-linearity is likely related to large changes in the required reserves component of base money for all three countries.

Overall, we are comfortable enough with the diagnostics of our individual country baseline regressions to use the results as we have done to draw conclusions for the group as a whole.

<u>Table 5.10</u>: Summary of Results for Diagnostic Tests of Individual Country Real Base Money Growth Baseline Regressions

Country	AR variables	Diagnostic Tests	Country	AR variables	Diagnostic Tests
China	✓	Serial correlation*^	Peru	✓	Serial correlation#^
Hong Kong		Serial correlation#^	Czech Republic	✓	Non-normality* Serial correlation*^
India	✓	Serial correlation#^ RESET failure**	Egypt	✓	
Indonesia	✓		Hungary	✓	Serial correlation*^
Korea	✓	Serial correlation#^	Israel	✓	Heteroskedasticity*
Malaysia	✓	RESET failure***	Poland	✓	Serial correlation**
Philippines		Serial correlation**	Russia		Serial correlation**
Singapore	✓	Serial correlation#^	South Africa	✓	
Taiwan	✓	Serial correlation#^	Turkey	✓	
Thailand	✓	Serial correlation*#	Australia	✓	Non normality*** Serial correlation*
Argentina	✓	Serial correlation#^	Canada	✓	
Brazil	✓	Serial correlation#^ RESET failure**	Denmark	✓	
Chile	✓		Japan	✓	Serial correlation**
Colombia	✓	Serial correlation*	New Zealand		Non normality*** Serial correlation#^
Mexico	✓	Non-normality*; Serial correlation **#	Norway	✓	

✓ Indicates presence of lagged values of the dependent variable as regressors.
***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.
Serial correlation or heteroscedasticity detected in the unrestricted regression only. No evidence of serial correlation or heteroscedasticity in the final parsimonious regression.
^ Of the serial correlation tests, the Breusch-Godfrey LM statistic (NR^2) is significant but not the F-statistic for the joint significance of all lagged residuals.

5.2.4 Robustness Analysis

In order to assess the robustness of the baseline coefficients we presented in Table 5.1, we undertake three tasks in this section. First we assess if using robust standard errors for those countries that displayed mixed results in the tests for serial correlation would substantially change the outcomes on the intervention effects. Next, we compare the results from the baseline regressions against the results from unrestricted regressions. Thirdly, we also consider the stability of the coefficients from the baseline regressions over time.

5.2.4.1 Robust Standard Errors for Selected Individual Country Regressions

For some of our individual country baseline regressions, we used robust standard errors, in particular, based on the Newey-West HAC covariance matrix method since serial correlation appeared to be more prevalent than heteroscedasticity. We used these only when there was consistency in the results of the F-test and LM test for serial correlation as we wanted to balance the need for more accurate statistical inference against the possible adverse effects of small sample sizes on the performance of the LM test and the robust standard errors.

In this subsection, we apply robust standard errors to the baseline regressions that display serial correlation, either in the unrestricted form or in the final parsimonious specification, as indicated by the LM test, even if the F-test does not provide similar evidence. The robust standard errors are used from the beginning of the estimation in our general to specific modelling approach. Consequently, since the standard errors are now different, the remaining variables in the final parsimonious specifications and the coefficients for real intervention effects may differ from the baseline versions. The results for the coefficients on real intervention effects for the countries in question are reported in Table 5.11. The results differ noticeably from the baseline coefficients for Argentina, Brazil, the Czech Republic, Hungary and Australia.

Table 5.11: Robustness Analysis of Real Intervention Effects on Real Base Money Change – Use of Robust Standard Errors for Selected Countries

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Hong Kong	0.272*** [3.963]	0.130 [1.701]
	1999q4-2010q2	
India	0.157*** [2.870]	0.225*** [26.891]
	1997q1-2010q2	
Korea	-0.102*** [-3.012]	-0.042 [1.376]
	1991q1-2010q2	
Singapore	0.010 [0.816]	0.035*** [22.274]
	1990q3-2010q2	
Argentina	0.079 [1.476]	0.089 [1.256]
	1994q4-2010q2	
Brazil	-0.100 [-0.798]	-0.086 [0.086]
	1997q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i} / (1 - \sum_{i=1}^{4} \beta_{1i})$ = 0.
- For both the t- and F-statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$which is not removed in the general to specific modelling process.

Table 5.11: Continued

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Peru	0.021** [2.079]	0.112*** [233.39]
	1995q2-2010q2	
Czech Republic	0.097*** [3.906]	0.180*** [10.517]
	1997q2-2010q2	
Hungary	0.072*** [4.422]	0.145*** [67.918]
	1995q4-2010q2	
Australia	0.054 [0.357]	-0.122 [1.273]
	1991q2-2010q2	
Denmark	-0.016 [-0.761]	0.016 [0.388]
	1991q1-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ which is not removed in the general to specific modelling process.

The effects of the changes to the selected coefficients based on the use of the robust standard errors are assessed by re-evaluating the equality tests and bivariate regressions that were carried out in subsection 5.2.2. The statistical significances (and signs on coefficients) of the regressors in the bivariate regressions appear not to be affected by the revised intervention coefficients. In Table 5.12 we highlight the results for equality tests of intervention coefficients based on the country groups from Table 5.5, and equality tests of characteristics based on the new boxplot quartiles[80] (baseline scenario: Tables 5(a) and 5(b)) and the subgroups of coefficient sizes (baseline scenario: Tables 5(c) and 5(d)), for which there are changes to statistical significance. With regard to the first and second sets of tests, there are only two instances of changes to statistical significance (Table 5.12, sections (a) and (b)).

For the third set, we only report the results relating to long-run intervention effects[81] (Table 5.12, section (c)), since with regard to the short-run coefficients, the subgroups are the same as the new boxplot quartiles. Here, we find relatively more changes to statistical significance, indicating, in particular, differences in capital account characteristics. We, nevertheless, observe that the capital account average balance (KAB) and surplus years (KAS), and the net direct investment and portfolio balance (DIPIB) do not follow a clear monotonic pattern in line with the averages of the subgroups of intervention coefficients. For these characteristics, there are no differences between the >0.100 and <0 subgroups of intervention coefficients. Generally, it is the middle group of coefficients (<0.100, >0) that registers the lowest average/median value among the characteristics. However, we observe that the lowest average intervention volatility (FXIV) is associated with the <0 subgroup of intervention coefficients and registers a statistically significant difference against the other two subgroups. The highest average other investment balance surplus years (OIS) is associated with the >0.100 subgroup of intervention coefficients and registers a statistically significant difference against the other two subgroups. In contrast, the highest average net direct investment and portfolio balance surplus years (DIPIS) is associated with the <0 subgroup of intervention coefficients and registers a statistically significant difference against the other two subgroups.

80 The number of countries in each quartile is 7, 13, and 8 respectively for the short-run coefficients and 6, 16, and 6 respectively for the long-run coefficients.

81 The number of countries in each of the subgroups of long-run coefficients is 11, 9, and 8 respectively.

Table 5.12: Sensitivity Analysis of Equality Tests with the use of Robust Standard Errors for Selected Countries

(a) Differences in Long-run Intervention Effects between Groups of Countries

Monetary Policy Framework	Group Median of Intervention Effect	Equality Test Statistic
Inflation-targeting	0.035	1.427
Non-inflation-targeting	0.089	

Baseline scenario reference: Tables 5.5

(b) Differences in Country Characteristics Grouped by Boxplot Quartiles of Long-run Intervention Effects

Country Characteristic	Subgroup Average of Characteristic			Equality Test Statistic
	Upper quartile	Inter-quartile	Lower quartile	
Income level	15.229	18.500	10.863	1.330

Baseline scenario reference: Tables 5.6(b)

(c) Differences in Country Characteristics Grouped by Coefficient Sizes of Long-run Intervention Effects

	Country Characteristic	Subgroup Average/[Median] of Characteristic for Intervention Effects:			Equality Test Statistic
		>0.100	<0.100, >0	<0	
1.	Current account openness	[0.711]	[0.807]	[0.614]	1.292
2.	Capital account average balance	[3.562]	[0.140]	[2.568]	6.260**
3.	Capital account surplus years	0.744	0.496	0.756	3.216*
4.	Net direct and portfolio investment average balance	[2.680]	[0.430]	[2.727]	5.119*
5.	Net direct and portfolio investment balance surplus years	0.702	0.614	0.891	4.513**
6.	Net other investment balance surplus years	0.602	0.372	0.470	3.397**
7.	Intervention volatility	0.874	0.941	0.519	3.332*

Baseline scenario reference: Tables 5.6(d)

The results presented are only those for which there have been changes to the statistical significance of the equality test statistics in comparison to the baseline scenario.
Differences in mean/median: ***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

5.2.4.2 Real Intervention Effects from Unrestricted Regressions

Next, in Tables 5.13 and 5.14 we present the results for the short-run and long-run coefficients that are derived from unrestricted regressions. By unrestricted, we mean that all the lags of all the explanatory variables as per equation (5.1) have been kept intact, regardless of statistical significance. We still include the impulse dummy variables that also appear in the restricted regressions for some of the countries. While statistical significance declines across the board, which is not unexpected given the increase in the number of explanatory variables, the variation in terms of economic significance is minimal as observed from the group averages. Furthermore, the sample correlations between the unrestricted regression results and the baseline restricted regression results are quite high at 0.97 and 0.89 for the short-run and long-run coefficients respectively (0.94 and 0.83 respectively if Israel and Japan are excluded).

We re-evaluate the equality tests and bivariate regressions using the coefficients from the unrestricted regressions. In Table 5.15, we highlight the results for equality tests of intervention coefficients based on the country groups from Table 5.5, and equality tests of characteristics based on the new boxplot quartiles[82] (baseline scenario: Tables 5(a) and 5(b)) and the subgroups of coefficient sizes[83] (baseline scenario: Tables 5(c) and 5(d)), for which there are changes to statistical significance. For the first set of tests, the only variation against the baseline scenario is that the difference in long-run intervention coefficients between inflation-targeting and non-inflation-targeting countries is no longer statistically significant (Table 5.15, section (a)). For the second set of tests, we observe that with regard to the short-run real intervention effects, the changes are mostly to statistical significance in differences of country characteristics, but for the long-run real intervention effects, the changes are to statistical insignificance. Crucially, however, we find that the relative sizes or ordering (monotonic or otherwise) of the characteristics in question are generally unchanged when compared against the baseline scenario (Table 5.15, sections (b) and (c)). With regard to the third set of tests, we note that changes occur particularly in relation to the characteristics corresponding to the subgroups for long-

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[82] The number of countries in each quartile is 7, 14, and 7 respectively, for both the short-run and long-run coefficients.

[83] The number of countries in each subgroup is as follows: 6, 13 and 9 respectively for the short-run coefficients, and 12, 9 and 7 respectively for the long-run coefficients.

run real intervention effects. In contrast to the baseline scenario, differences in current account and capital account openness are no longer statistically significant. On the other hand, differences in current account and capital account balances are now statistically significant. However, similar to the baseline scenario and our first section on robustness analysis, the differences in characteristics do not follow a monotonic ordering in line with the averages of the subgroups of coefficients.

In Table 5.16, we highlight the results from bivariate regressions which have been carried out using the revised intervention coefficients. Only two changes to statistical significance are noted, and even so, the coefficients on the regressors do not vary much from the baseline scenario.

<u>Table 5.13</u>: Robustness Analysis of Real Intervention Effects on Real Base Money Change - Individual Country Results from Unrestricted Regressions

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Asia		
China	0.045 [0.780]	0.014 [0.012]
	1991q2-2010q2	
Hong Kong	0.319* (2.149)	0.138 (0.170)
	1999q1-2010q2	
India	0.185* (1.914)	0.190** (5.514)
	1997q3-2010q2	
Indonesia	-0.049 (-0.414)	0.020 (0.009)
	1995q2-2010q2	
Korea	-0.083 (-1.645)	-0.056 (0.984)
	1991q2-2010q2	
Malaysia	0.035 (1.353)	0.022 (0.165)
	1990q2-2010q2	
Philippines	-0.035 (-0.451)	-0.066 (0.139)
	1990q2-2010q2	
Singapore	0.008 (0.604)	0.040*** (8.261)
	1991q2-2010q2	
Thailand	0.029 [0.683]	-0.017 [0.097]
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i} / (1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

<u>Table 5.13</u>: Continued

Country	The effect of $\Delta \text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Latin America		
Argentina	0.092 (1.266)	0.091 (0.287)
	1995q2-2010q2	
Brazil	-0.061 (-0.330)	0.012 (0.001)
	1997q4-2010q2	
Chile	0.041 (1.032)	0.048 (0.659)
	1991q2-2010q2	
Colombia	0.165 [1.267]	0.504*** [14.618]
	1995q2-2010q2	
Mexico	-0.057** [-2.397]	-0.030 [0.391]
	1991q2-2010q2	
Peru	0.022* (1.773)	0.117*** (16.025)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

Table 5.13: Continued

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Other Emerging Market Economies(EMEs)-Europe, Middle East and Africa		
Czech Republic	0.075 (1.494)	0.165** (4.762)
	1997q2-2010q2	
Hungary	0.064 (1.090)	0.107 (1.646)
	1996q2-2010q2	
Israel	0.554*** {4.788}	0.546** {5.533}
	1991q2-2010q2	
Poland	-0.010 [-0.422]	0.147 [0.363]
	1998q1-2010q2	
Russia	0.231** [2.490]	0.162 [1.081]
	1996q3-2010q2	
South Africa	0.074 (1.102)	0.118* (3.482)
	1991q2-2010q2	
Turkey	-0.014 (-0.235)	-0.250 (1.416)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

Table 5.13: Continued

Country	The effect of $\Delta \text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Developed Economies		
Australia	-0.005 (-0.242)	-0.215 (0.629)
	1991q2-2010q2	
Canada	0.033 {0.886}	0.019 {0.174}
	1991q2-2010q2	
Denmark	-0.008 (-0.287)	-0.043 (0.979)
	1991q1-2010q2	
Japan	0.301 [1.014]	0.501 [0.699]
	1991q2-2010q2	
New Zealand	0.043 [1.198]	0.368** [6.165]
	1991q2-2010q2	
Norway	0.061 (1.029)	0.058 (0.193)
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

Table 5.14: Robustness Analysis of Real Intervention Effects on Real Base Money Change - Group Averages based on Unrestricted Regressions

Group	The group average effect of $\Delta \text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Asia	0.050 (1.110)	0.032 (1.706)
Latin America	0.034 (1.344)	0.124** (5.330)
Other EMEs	0.139* (1.660)	0.142 (2.612)
Developed Economies	0.071 (0.775)	0.115 (1.473)
TOTAL	**0.073** **(1.226)**	**0.097** **(2.659)**
Sample standard deviation	*0.138*	*0.191*
Correlation with restricted regression results:	*Correlation (t-statistic)*	
Full sample	*0.97**** *(19.382)*	*0.89**** *(9.798)*
Excluding Israel and Japan	*0.94**** *(13.835)*	*0.83**** *(7.202)*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average t statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the t and F statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.
- Data excludes Egypt and Taiwan.

Table 5.15: Sensitivity Analysis of Equality Tests with the use of Results from Unrestricted Regressions

(a) Differences in Long-run Intervention Effects between Groups of Countries		
Monetary Policy Framework	**Group Mean of Intervention Effect**	**Equality Test Statistic**
Inflation-targeting	0.084	0.261
Non-inflation-targeting	0.124	
Baseline scenario reference: Tables 5.5		

(b) Differences in Country Characteristics Grouped by Boxplot Quartiles of Short-run Intervention Effects					
Country Characteristic		**Subgroup Average/[Median] of Characteristic**			**Equality Test Statistic**
		Upper quartile	**Inter-quartile**	**Lower quartile**	
1.	Net direct and portfolio investment balance surplus years	0.577	0.723	0.881	3.742*
2.	Intervention volatility	0.843	0.918	0.497	4.429**
3.	Surplus quarters	0.655	0.627	0.666	0.319
4.	Income level	16.029	18.264	9.443	2.923*
Baseline scenario reference: Tables 5.6(a)					
(c) Differences in Country Characteristics Grouped by Boxplot Quartiles of Long-run Intervention Effects					
1.	Capital account openness	[0.163]	[0.150]	[0.119]	0.762
2.	Net direct and portfolio investment balance surplus years	0.678	0.701	0.831	0.632
3.	Net other investment balance surplus years	0.589	0.400	0.573	2.821*
4.	Intervention volatility	0.702	0.938	0.598	1.538
5.	Income level	15.229	15.957	14.857	0.023
Baseline scenario reference: Tables 5.6(b)					

The results presented are only those for which there have been changes to the statistical significance of the equality test statistics in comparison to the baseline scenario.
Differences in mean/median: ***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 5.15: Continued

	Country Characteristic	Subgroup Average/[Median] of Characteristic for Intervention Effects: >0.100	<0.100, >0	<0	Equality Test Statistic
(d)	**Differences in Country Characteristics Grouped by Coefficient Sizes of Short-run Intervention Effects**				
	Current account openness	[0.544]	[0.807]	[0.642]	2.278
Baseline scenario reference: Tables 5.6(c)					
(e)	**Differences in Country Characteristics Grouped by Coefficient Sizes of Long-run Intervention Effects**				
1.	Current account openness	[0.675]	[0.798]	[0.794]	0.046
2.	Capital account openness	[0.148]	[0.166]	[0.119]	0.271
3.	Current account average balance	[-2.025]	[3.436]	[0.116]	5.674*
4.	Capital account average balance	[3.551]	[0.140]	[2.496]	6.826**
5.	Net other investment balance surplus years	0.583	0.303	0.573	7.412***
6.	Net other investment average balance	[0.579]	[-0.660]	[0.464]	6.390**
Baseline scenario reference: Tables 5.6(d)					

The results presented are only those for which there have been changes to the statistical significance of the equality test statistics in comparison to the baseline scenario.
Differences in mean/median: ***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 5.16: Sensitivity Analysis of Bivariate Regressions with the use of Results from Unrestricted Regressions

Country Characteristic (Regressor in bivariate regression)	Dependent Variable: Short-run Real Intervention Effect — Coefficient	t-statistic
Net direct and portfolio investment balance (DIPIB)	-1.194	-1.815*
Baseline scenario reference: Table 5.8		
	Dependent Variable: Long-run Real Intervention Effect	
Net direct and portfolio investment balance surplus years (DIPIS)	-0.172	-1.332
Baseline scenario reference: Table 5.9		

The results presented are only those for which there have been changes to the statistical significance of the regressors in comparison to the baseline scenario.
***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

5.2.4.3 Stability Analysis of Baseline Real Intervention Effects

We now turn to analysing the stability of the baseline coefficients over time. Using each country's final parsimonious specification, we run regressions from the beginning of the sample period specific to each country, up to 2000q4 and 2005q4 respectively. In Table 5.17, we compare the coefficients on real intervention effects on changes in real base money from these regressions against the coefficients from the baseline regressions. Some instability is not unexpected particularly given changes in monetary policy frameworks, and the use of reserve requirements and monetary deposit auctions which can be volatile over time.

The averages for the coefficients across the full set of countries appear to be fairly stable over time. To be able to make inferences about the statistical significance of the variations in coefficients that we observe in Table 5.17, we formally test for breakpoints. We test for changes in the constant and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money. The latter are included in the group of parameters to be tested for stability since they matter for the long-run effects of intervention. On the basis of a single unknown breakpoint, in Table 5.18, we report the Quandt-Andrews supremum or maximum Wald statistic (sup-W), which is the maximum of a sequence of Chow type test statistics calculated for different potential breakpoints and thus allows for the identification of the most likely location for a breakpoint. We also report the Andrews-Ploberger average of exponential Wald statistics (exp-W), which is the average of the exponential of the same sequence of test statistics. The asymptotic distributions for these statistics are non-standard[84]. Conducting the traditional Chow test by drawing on features of the data to ascertain a breakpoint would too often lead to the rejection of the null hypothesis of no structural change based on the limiting chi-square distribution

[84] For the identification of the most likely breakpoint date, Andrews (1993) considers the maximum Wald, Lagrange Multiplier (LM) and Likelihood Ratio (LR) test statistics and determines the associated non-standard asymptotic null distributions and critical values. E-Views reports the maximum Wald statistic and the Quandt Likelihood Ratio (QLR) test statistic, derived in Quandt (1960). The QLR is the maximum of the sequence of F-statistics based on the comparison of restricted and unrestricted sums of squared residuals. There is no difference in the reported p-values of these two statistics which are based on Hansen (1997). Andrews and Ploberger (1994) derive Wald, LM and LR average statistics, computed by taking the simple average of the sequence of test statistics and the average of the exponential of the sequence of test statistics respectively. Andrews and Ploberger show that the exponential form of the test statistic may have higher power, and that the LR versions of both, the simple average and average of the exponential values, are less than optimal. As such, we report the average of the exponential Wald statistics (exp-W). We note that the p-value differs from that for the average of the exponential F-statistics used to calculate the QLR, and is more likely to reject the null hypothesis.

(Hansen, 2001). We, nevertheless, also present results of the traditional Chow F-test for known breakpoint, using the mid-point of the regression sample period for each country as the breakpoint to be tested. We note that such an approach may limit the power of the Chow test in establishing a true breakpoint (see, for instance, Hansen (2001) and Greene (2003)).

The results indicate that the coefficients on the real intervention effects have been relatively stable over time for most countries. The countries exhibiting evidence of instability based on the statistical significance of the Quandt-Andrews/Andrews-Ploberger and Chow test statistics are Mexico, Peru, and Japan. For Colombia, the Czech Republic and to a lesser extent, South Africa, there are indications of instability based on the Quandt-Andrews/Andrews-Ploberger set of test statistics but not the Chow test.

The statistically significant breakpoints for Mexico, Peru and Colombia roughly coincide with changes in the monetary policy frameworks in these countries and the gradual move to inflation-targeting. For the Czech Republic and South Africa, the breakpoints do not coincide with the move to inflation targeting but may be connected to particular changes that occurred in the respective countries. In the Czech Republic, a gradual reduction in the reserve requirement ratio took place in the late 1990s and a special account with the Czech National Bank for the government’s foreign exchange revenues from privatisation was established in early 2000. For South Africa, the dual exchange rate system was abolished in March 1995. In the case of Japan, the breakpoint appears to coincide with the interim lifting of the zero interest rate policy in August 2000 before the subsequent implementation of banks’ current account balances as the operational target.

In *Appendix 5*, we present the results of Chow tests for selected countries, carried out for the specific dates where known changes to monetary policy frameworks have taken place. These changes encompass shifts to inflation-targeting, changes to the monetary policy instrument and for a few countries, significant changes in reserve requirement ratios. We recognise that the Quandt-Andrews test may exhibit low power in the presence of multiple breaks and that the Chow test can be used to test for the significance of more than one known breakpoint. Some of the dates for the changes to monetary policy frameworks coincide with or are close to the most likely break date identified through the Quandt-Andrews test and which were reported in Table 5.18.

The Chow test results indicate that, for some countries, the dates corresponding to changes to monetary policy frameworks appear to entail statistically significant changes to real intervention effects. There is consistency with the Quandt-Andrews test in the case of Colombia, Mexico, Peru and Japan. The Chow test suggests strong statistical significance of a break for New Zealand, where none was picked up by the Quandt-Andrews test because of large trimmings that excluded the break date from analysis. The Chow test results also indicate weak statistical significance of breaks for Malaysia, Brazil, Israel and Turkey. Comparing and contrasting the results across countries does not yield a clear pattern on the implications of changes to monetary policy frameworks for real intervention effects. In particular, the move to inflation-targeting is associated with statistically significant breaks for some countries but not for others, even if changes to the monetary policy instrument (namely from base money to interest rates) occur for both groups at the time of the shift. On the other hand, a clear cut and rather extreme case of the relevance of the monetary policy instrument for breaks is Japan which exhibits multiple breaks associated with changes in the role of its base money.

As an indication of the overall stability of the regression specifications we have used in our baseline analysis, we present the results of tests for stability across all parameters, in *Appendix 6*. The results do not indicate a noticeably greater amount of instability compared to the tests that focus on the subset of real intervention effects[85]. Compared to the results in Table 5.18, there are additionally, indications of instability for India, Malaysia, Argentina, New Zealand, and to a lesser extent, Korea. It is likely that the break for the Czech Republic is not picked up despite consideration of the full set of parameters because of large trimmings.

[85] We also carried out the Bai-Perron test for (see Bai and Perron (1998)) multiple breaks across the full set of parameters. There are some differences when compared against the results of the Quandt-Andrews test as follows: (i) the Bai-Perron test identifies one break for Hong Kong, two breaks for the Philippines, one for Canada, and three for Norway in contrast to none being statistically significant under the Quandt-Andrews test; (ii) three breaks are identified for Mexico, and two breaks are identified for Japan and New Zealand respectively; and (iii) for Argentina, Colombia, Malaysia and South Africa, the Bai-Perron test does not identify any breaks, in contrast to indications of some statistically significant instability based on the Quandt-Andrews test. The Bai-Perron test is subject to distortions in power and size (see Antoshin et al. (2008)), but nevertheless provides a check for the robustness of our stability analysis.

Table 5.17: Results from Recursive Regressions for Real Intervention Effects on Real Base Money Change

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{res,t-1}$ on $\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$					
	Short-run Coefficient (for sample ending)			Long-run Coefficient (for sample ending)		
	2000q4	**2005q4**	**2010q2**	**2000q4**	**2005q4**	**2010q2**
Asia						
China	0.275**	0.192**	0.158**	0.125	-0.056	0.043
Hong Kong	n.a.	0.225**	0.270**	n.a.	0.114	0.155**
India	n.a.	0.047	0.157**	n.a.	0.210***	0.216***
Indonesia	-0.157	-0.107	-0.100	-0.161	-0.140	-0.124
Korea	0.001	-0.080*	-0.086*	0.001	-0.056*	-0.051**
Malaysia	0.057	0.033	0.041**	0.205**	0.090**	0.084***
Philippines	-0.115***	-0.075*	-0.076*	-0.115***	-0.075*	-0.076*
Singapore	0.017	0.009	0.008	0.033*	0.034***	0.039***
Thailand	-0.020	0.008	0.030	-0.050	-0.026	-0.017
Latin America						
Argentina	0.108	0.150**	0.116**	0.086	0.329	0.152
Brazil	n.a.	0.004	-0.030	n.a.	0.006	-0.043
Chile	0.013	0.009	0.026	0.032	0.025	0.054*
Colombia	0.012	0.078	0.144*	0.354*	0.401***	0.362***
Mexico	-0.074***	-0.071***	-0.062***	-0.052***	-0.054***	-0.046***
Peru	n.a.	0.046***	0.030***	n.a.	0.112***	0.128***

Regressions are estimated recursively using each country's full sample baseline estimating equation. Coefficient estimates are reported based on the regressions run from the beginning of the sample to 2000q4, 2005q4 and 2010q2 respectively, depending on the available sample size. The 2010q2 results correspond to those in Table 5.1 and are reported here for comparison purposes.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.
n.a. Not available or not reported, on account of short sample period.

Table 5.17: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $RM_{res,t-1}$ on ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$					
	Short-run Coefficient (for sample ending)			Long-run Coefficient (for sample ending)		
	2000q4	2005q4	2010q2	2000q4	2005q4	2010q2
Other Emerging Market Economies						
Czech Republic	n.a.	0.062	0.069*	n.a.	0.040	0.048*
Hungary	0.109	0.010	0.035	0.082	0.057	0.090***
Israel	0.554***	0.556***	0.563***	0.765***	0.778***	0.688***
Poland	n.a.	-0.035	-0.011	n.a.	0.082	0.113
Russia	0.238**	0.447***	0.264***	0.240	0.453***	0.253***
South Africa	0.052	0.033	0.057	0.064	0.071*	0.084**
Turkey	0.081	0.035	-0.012	0.067	0.047	-0.012
Developed Economies						
Australia	-0.156	-0.160	-0.011	-0.120	-0.117	-0.007
Canada	0.058	0.020	0.027	0.080**	0.058**	0.055**
Denmark	-0.028	-0.018	-0.015	-0.014	-0.010	-0.008
Japan	0.561***	0.443***	0.425**	0.609**	0.576***	0.636**
New Zealand	0.005	0.017	0.046	0.048	0.064**	0.278***
Norway	0.018	0.049	0.034	0.012	0.035	0.024
*Average for all countries^*	*0.073*	*0.069*	*0.075*	*0.104*	*0.109*	*0.111*

Regressions are estimated recursively using each country's full sample baseline estimating equation. Coefficient estimates are reported based on the regressions run from the beginning of the sample to 2000q4, 2005q4 and 2010q2 respectively, depending on the available sample size. The 2010q2 results correspond to those in Table 5.1 and are reported here for comparison purposes.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.
n.a. Not available or not reported, on account of short sample period.
^Average excludes Hong Kong, India, Brazil, Peru, the Czech Republic and Poland for the sample period ending 2000.

Table 5.18: Structural Break Tests for Real Intervention Effects on Real Base Money Change

Country	Quandt-Andrews/ Andrews-Ploberger Tests[#]			Chow Test[#]	
	Unknown Breakpoint [Trimming]	Sup-W Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Asia					
China	2007q2 [15%]	8.354 (0.941)	1.822 (0.991)	2001q1	0.209 (0.982)
Hong Kong	2008q2 [15%]	11.993 (0.339)	3.724 (0.304)	2005q1	1.006 (0.436)
India	2006q1 [15%]	13.170 (0.378)	4.208 (0.349)	2004q1	0.821 (0.561)
Indonesia	2007q4 [15%]	11.342 (0.707)	3.890 (0.577)	2003q1	0.842 (0.559)
Korea	2004q2 [15%]	11.208 (0.574)	3.844 (0.833)	2001q1	0.957 (0.462)
Malaysia	1997q4 [15%]	13.326 (0.364)	4.257 (0.339)	2000q3	1.391 (0.233)
Philippines	2000q3 [49%]	2.670 (0.352)	1.290 (0.278)	2000q3	1.335 (0.270)
Singapore	2000q3 [49%]	7.468 (0.692)	3.733 (0.603)	2000q4	1.410 (0.207)
Thailand	1997q3 [15%]	8.015 (0.957)	2.645 (0.886)	2001q1	0.628 (0.730)
Latin America					
Argentina	2000q4 [15%]	14.225 (0.557)	5.689 (0.325)	2002q4	1.755 (0.118)
Brazil	1999q2 [15%]	8.558 (0.338)	2.438 (0.264)	2004q1	0.535 (0.661)
Chile	1993q4 [15%]	4.877 (0.940)	1.285 (0.879)	2000q4	0.401 (0.807)
Colombia	1999q1 [15%]	24.583** (0.036)	9.745** (0.021)	2003q1	1.562 (0.167)
Mexico	2000q4 [49%]	33.867*** (0.000)	16.416*** (0.000)	2001q1	4.367*** (0.000)
Peru	2002q2 [20%]	24.922** (0.048)	9.781** (0.035)	2003q1	2.272** (0.048)

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Table 5.18: Continued

Country	Quandt-Andrews/ Andrews-Ploberger Tests[#]			Chow Test[#]	
	Unknown Breakpoint [Trimming]	Sup-W Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Other Emerging Market Economies					
Czech Republic	2000q2 [15%]	17.825** (0.027)	5.646** (0.032)	2004q1	0.547 (0.702)
Hungary	1999q4 [15%]	13.416 (0.499)	4.390 (0.453)	2003q3	0.657 (0.706)
Israel	1995q4 [15%]	15.905 (0.403)	5.415 (0.376)	2000q4	0.433 (0.896)
Poland	2008q3 [15%]	9.702 (0.576)	1.965 (0.814)	2004q2	0.467 (0.798)
Russia	2007q3 [15%]	12.509 (0.439)	4.376 (0.315)	2003q4	1.337 (0.267)
South Africa	1995q3 [15%]	18.447* (0.084)	6.422* (0.075)	2001q1	0.692 (0.657)
Turkey	1998q1 [15%]	10.278 (0.350)	4.018 (0.135)	2003q1	1.521 (0.212)
Developed Economies					
Australia	1997q3 [20%]	14.966 (0.312)	5.620 (0.209)	2001q1	1.813 (0.105)
Canada	2000q3 [40%]	16.062 (0.230)	6.794 (0.178)	2000q4	1.438 (0.194)
Denmark	2004q1 [15%]	10.218 (0.518)	2.560 (0.620)	2001q1	0.395 (0.850)
Japan	2000q2 [49%]	17.385** (0.026)	8.692** (0.015)	2000q3	2.484** (0.026)
New Zealand	2000q4 [49%]	6.598 (0.581)	3.191 (0.507)	2001q1	0.877 (0.531)
Norway	2000q1 [45%]	4.319 (0.765)	1.623 (0.710)	2001q1	0.374 (0.864)

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

5.3 CONCLUSION

In this chapter, we set out to investigate the effects of real intervention on changes in real base money over the period 1990q1-2010q2. Because of the nature of the components of base money, our hypothesis was that strong effects were unlikely unless under specific circumstances. We proposed that these circumstances had to do with exceptional monetary policy frameworks, such as a currency board or a policy of monetary base expansion/quantitative easing; and the nature of instruments, noting that the use of required reserves would lead to base money expansion.

Our first stage of empirical analysis was carried out using individual country multivariate dynamic regressions for a sample of 30 countries. This allowed us to consider short-run and long-run effects separately and also to bring attention to individual country peculiarities. We find that on average, the intervention effect on base money is low - the baseline group average short-run and long-run coefficients are 0.075 and 0.111 respectively, excluding outliers, Egypt and Taiwan. However, there is substantial dispersion among countries, especially where the positive signed coefficients are concerned. For a subset of countries with economically significant coefficients, we analysed the effects of intervention on the components of base money: currency in circulation and required reserves/deposit accounts with the central bank. We discussed how the empirical evidence of positive coefficients tied in with the monetary policy frameworks and the nature of instruments used, namely required reserves and monetary deposit auctions, among these countries. For instance, the highest coefficients on intervention effects were observed for Japan, which had a policy of base money expansion and Israel, which actively used monetary deposit auctions as a sterilisation instrument.

In the second stage, to better understand the individual country results revealed by the empirical analysis, we also performed mean and median equality tests and bivariate regressions to investigate the relevance of country characteristics in terms of region; the nature of intervention (volatility, the proportion of surplus periods and reserve accumulation); income levels; current account and capital account openness and net positions; exchange rate flexibility; and monetary policy frameworks - whether the countries are inflation-targeting or non-inflation-targeting. Correlation analyses between the country characteristics reveal that intervention volatility and reserve accumulation are positively and strongly correlated with the average current account balance and negatively correlated (either with statistical significance or without statistical significance) with the average capital account balance and the average balances on its subaccounts.

Generally, we find that there are only a few instances of statistical significance for the relevance of country characteristics to intervention effects on changes in base money. In terms of monetary policy frameworks, median equality tests point towards a difference between inflation-targeting and non-inflation-targeting countries particularly in the context of short-run intervention effects. However, the statistical significance of this difference owes much to the uniqueness of the monetary policy frameworks of Hong Kong and Japan in the non-inflation-targeting group and does not point to the inability to carry out sterilisation. Differences in exchange rate flexibility, on the other hand, are not statistically significant although the lowest intervention effects generally appear to be associated with the highest exchange rate flexibility.

Of the intervention indicators, there is mixed evidence of statistical significance for differences in intervention volatility based on the equality tests from the baseline scenario and the robustness analysis. The lowest intervention effects appear to be associated with the lowest intervention volatility. There is no similar indication of statistical significance for the differences in reserve accumulation.

Meanwhile, in terms of the relevance of balance of payment flows, the equality tests for the characteristics of countries based on the boxplot and alternative groupings of coefficients indicate the fairly robust statistical significance of differences in capital account openness. Crucially however, these differences do not occur between the upper and lower quartile groups – essentially, one cannot infer a difference in capital account openness between the countries with the largest real intervention effects and those with the smallest real intervention effects on changes in base money. This may reflect differences in monetary policy frameworks and sterilisation instruments. Nevertheless, the result is a tentative indication of the relevance of the gross size of capital flows rather than net balances.

The baseline set of equality tests suggest a few other statistically significant differences but these are sensitive to changes in the groupings of the coefficients, becoming statistically insignificant with the switch. In our robustness analysis, we find indications of statistically significant differences across a wider number of capital account related characteristics. However, like the baseline results, it is a common occurrence that the characteristics do not display a monotonic ordering consistent with the ordering of the groupings of intervention coefficients. Taking together the results of the baseline analysis and robustness checks for the equality tests and bivariate regressions, there is tentative evidence that higher coefficients on intervention effects are associated with a lower number of surplus years for the net direct and portfolio investment balance. This may relate to the negative correlation between intervention volatility and capital account surpluses – which points to a situation of low intervention rather than high sterilisation.

CHAPTER 6

AN EMPIRICAL ASSESSMENT OF THE EFFECTS OF FOREIGN EXCHANGE INTERVENTION ON BROAD MONEY

6.1 INTRODUCTION

In this chapter, we investigate the effects of real intervention on changes in real broad money. A detailed conceptual framework was presented in Chapter 4. Our hypothesis is that there are elements of disconnect between the effects of real intervention on changes in real base money and the effects of real intervention on changes in real broad money. Given this disconnect, it is important to draw attention to the effects of intervention on changes in broad money. As we saw in Chapter 5, the analysis of intervention effects on changes in base money takes on a distinctive technical slant, in that it primarily concerns liquidity management in the interbank money market alongside the private sector's demand for currency holdings. In contrast, the analysis of intervention effects on changes in broad money provides relatively more important information on how intervention related to trade and capital flows affects private sector liquidity and permeates the economy. The effects of intervention on changes in broad money depend on the type of balance of payments flows and the sectors involved; the nature of sterilisation methods; as well as the monetary policy stance. These are issues that have not been addressed in the existing literature.

While there is quite extensive empirical literature on the effects of intervention on changes in base money, there is a dearth of econometric analysis on the effects of intervention on changes in broad money, in terms of both individual country examination as well as cross-sectional studies. The reasons for this are unclear, but we can speculate that it arises from the tendency to focus on the narrow definition of sterilisation and to invoke the theoretical simplification of a constant money multiplier. Frankel (1994) and Frankel and Okongwu (1995) provide succinct clarification on the definitions of sterilisation. Narrowly defined sterilisation involves offsetting reserve inflows, mainly through open market operations, so as to leave base money unaffected. Sterilisation more broadly defined is the offsetting of inflows so as to leave the overall money supply unaffected, even if base money changes, for example through reserve requirements.

Without a strong supporting conceptual framework, the few studies that provide econometric analysis of the effects of intervention on broad money leave room for improvement. Takagi (1999), acknowledging the use of various measures to sterilise capital inflows in Asia, carries out multivariate regression analysis of the effect of a change in central bank foreign assets on the monetary aggregates, M1 and M2 respectively. This is done for five Asian economies. Contemporaneous values of control variables are used, but importantly, only the first-order lagged value of the change in foreign assets is considered as an explanatory variable in order to capture intervention effects on the monetary aggregates. This is justified by the author on the conceptual assumption that intervention affects the monetary aggregates over time through the banking system, and from an econometric viewpoint, to avoid simultaneity bias.

Reinhart and Reinhart (2008) estimate the effects of intervention on narrow money (M1) on a yearly basis over 2000-2006 using bivariate regressions of data from a cross-section of 30 developing countries. It is not made known why the authors choose M1 as the dependent variable rather than base money or a broader monetary aggregate to gauge sterilised intervention. The choice may have to do with M1 traditionally representing transaction balances.

Cardarelli *et al*. (2009) estimate narrow and broad sterilisation indices by region using pooled bivariate regressions of monthly country data to arrive at annual sterilisation coefficients. The relatively simple approach to the broad sterilisation measure involves the static regression of the change in the monetary aggregate, M2 against the change in net foreign assets (ΔNFA). They note (page 18) that the broad sterilisation index "reflects the central bank's effort to prevent the increase in monetary base from causing an expansion of money supply. This has generally occurred through an increase in the reserve requirements for the banking sector." However, the authors choose to utilise only the results for the narrow sterilisation index in their analysis, stating that the results are consistent with those of the broad sterilisation index.

Our contribution is to fill an evident gap in the empirical literature on the effects of intervention on changes in broad money. As in Chapter 5, we carry out multivariate dynamic regression analysis on an individual-country basis. We focus on the broad money aggregate that is typically consistent with a country's broadest national definition of money rather than the country's narrower aggregates, namely M1 and in some instances, M2. We do this because the narrower aggregates may not capture all the relevant financial assets classified as money and, crucially, those financial assets into which balance of payments flows are channelled. If the narrower aggregates were used, the effects of intervention on broad money could be understated.

The layout of this chapter is similar to that in Chapter 5, and the analysis concerns the same group of countries and time period. In Section 6.2 we describe our empirical approach briefly, following the detailed discussion in Chapter 4, and then analyse our baseline results in subsection 6.2.1. We compare our results to the findings on real intervention effects on changes in real base money which were discussed in Chapter 5. Next, we evaluate the role of different country characteristics in influencing the intervention effects in subsection 6.2.2 by using mean and median equality tests and bivariate regressions. We also discuss regression diagnostics for the baseline specification of each country and robustness checks in subsections 6.2.3 and 6.2.4 respectively. In Section 6.3, we conclude.

6.2 EMPIRICAL ANALYSIS

We estimate the real intervention effects on real broad money growth for each country using the following model specification. This estimating equation is similar to equation (5.1) but replaces the dependent variable with real broad money growth and includes the interest rate on bonds as an additional explanatory variable.

$$
\begin{aligned}
\Delta \mathrm{Real\ BM}_{br,t}/\mathrm{Real\ BM}_{br,t-1} &= \alpha_0 \\
&+ \sum_{i=1}^{4} \alpha_{1i} \Delta \mathrm{Real\ BM}_{br,t-i}/\mathrm{Real\ BM}_{br,t-i-1} \\
&+ \sum_{i=0}^{4} \alpha_{2i} \Delta \mathrm{Real\ FXR}_{cb,t-i}/\mathrm{Real\ BM}_{br,t-i-1} + \sum_{i=0}^{4} \alpha_{3i} \Delta \ln(\mathrm{Real\ GDP})_{t-i} \\
&+ \sum_{i=0}^{4} \alpha_{4i} \Delta \mathrm{IntRate(M)}_{t-i} \\
&- \sum_{i=0}^{4} \alpha_{5i} \Delta \mathrm{IntRate(B)}_{t-i} + \sum_{i=0}^{4} \alpha_{6i} \Delta \ln{(\mathrm{REER})}_{t-i} - \sum_{i=0}^{4} \alpha_{7i} \Delta (\mathrm{Inflation})_{t-i} \\
&+ \varepsilon_{1t}
\end{aligned}
\tag{6.1}
$$

The main coefficients of interest are the short-run and long-run effects of the change in real foreign exchange reserves (real intervention) on the change in real broad money. The short-run effect is the coefficient α_{20} while the long-run coefficient is derived as follows:

$$
\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ \left(1 - \sum_{i=1}^{4} \alpha_{1i}\right) \tag{6.2}
$$

If the short-run coefficient is zero, this indicates that real intervention does not have any unique contemporaneous effect on changes in real broad money in the presence of control variables. As discussed in Chapter 4, any of the following factors could explain the lack of impact, even before consideration of the control variables: intervention operations are mainly related to balance of payments flows that are associated with banking institutions or the government and therefore do not translate immediately into changes in broad money liabilities (deposits); there is sterilisation at the point of the private sector (resident or non-resident); or there is active use of foreign exchange swaps with banking institutions which may have broken the connection between intervention and the external flows to which they relate[86]. If the long-run coefficient is close to zero, then there are limited indirect effects of real intervention on changes in real broad money. This means that intervention-driven credit expansion and public sector spending do not occur and therefore do not influence changes in broad money over the long run above and beyond what is accounted for by the control variables.

We propose that real intervention can have statistically and economically significant effects on changes in real broad money whilst having no discernible effects on changes in real base money. The reverse is also a possibility. These dichotomous outcomes and variations in the broad money multiplier lend support to the importance of analysing the effects of real intervention on changes in real broad money.

[86] For example, if the central bank intervenes in the full amount of a current account surplus but does not sterilise broad money, we would expect broad money to change in line with intervention and the current account surplus. However, if the increase in foreign exchange reserves (our proxy for intervention) is swapped out to banks, the link between intervention and broad money change is broken.

6.2.1 Baseline Regression Results for the Real Intervention Effects on Real Broad Money Change

In Table 6.1, we present the results for each country based on the final parsimonious versions of the initial general unrestricted model (equation (6.1)). For each country, there are two columns of results in Table 6.1. Column (i) consists of the short-run coefficient on $\Delta\text{Real FXR}_{\text{cb,t}}/\text{Real BM}_{\text{br,t}-1}$ while column (ii) lists the corresponding long-run coefficient. For the short-run coefficients, t-statistics are reported while for the long-run coefficients, F-statistics are reported – both statistics are in brackets. We carry out the same general-to-specific approach as in Chapter 5, which we discussed in detail in section 5.2.1. In Table 6.2, subgroup averages and the average for all countries in the sample are reported. The results are those of simple averages of the coefficients and their associated average t- and F-statistics.

The results indicate that the effect of real intervention on changes in real broad money is on average, relatively low in the short run but noticeably higher in the long run, indicating the comparatively more prominent role of indirect effects. Excluding Taiwan and Egypt,[87] the average coefficients for the remaining sample of 28 countries are 0.122 in the short run and 0.469 in the long run respectively. In effect, a one unit increase in real intervention only leads to a 0.122 unit increase in the change in real broad money in the short run but a 0.469 unit increase in the long run. Of interest, these coefficients are respectively 1.6 and 4.2 times higher than the coefficients for the short-run and long-run effects of real intervention on changes in real base money as seen in Chapter 5.

[87] We exclude Egypt as the short-run and long-run coefficients for the effects of real intervention on changes in real base money are exceptionally large and based upon regressions covering a short sample period (see Chapter 5). The sample period differs considerably from that which is used in the real broad money growth regression in this chapter. In the case of Taiwan, the long-run coefficient of the effect of real intervention on changes in real broad money is exceptionally large and statistically insignificant. In order to have the same sample of countries when we compare the coefficients from the real base money growth regression against those from the real broad money growth regression, we thus exclude both these countries in our analysis.

Table 6.1: Real Intervention Effects on Real Broad Money Change - Individual Country Results

Country	The effect of $\Delta \text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$ (i) Contemporaneous α_{20}	(ii) Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Asia		
China	-0.103 [-0.647]	0.743*** [9.289]
	1991q2-2010q2	
Hong Kong	0.331 (1.145)	1.316** (6.349)
	1998q1-2010q2	
India	0.288* (1.960)	0.297 (1.092)
	1997q3-2010q2	
Indonesia	0.440** [2.334]	0.357** [5.840]
	1995q2-2010q2	
Korea	0.048 [0.290]	-0.752** [5.479]
	1990q2-2010q2	
Malaysia	0.201*** (3.935)	0.042 (0.187)
	1990q4-2010q2	
Philippines	0.042 (0.246)	1.396** (4.171)
	1991q1-2010q2	
Singapore	0.169*** (2.656)	0.374** (5.404)
	1990q2-2010q2	
Taiwan	0.464*** (4.012)	6.272 (0.107)
	1991q2-2010q2	
Thailand	0.191* (1.825)	1.792*** (9.944)
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta \text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ which is not removed in the general to specific modelling process.

Table 6.1: Continued

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Latin America		
Argentina	0.512*** [2.857]	0.379** [6.513]
	1994q4-2010q2	
Brazil	0.199*** [2.792]	0.041 [0.025]
	1997q4-2010q2	
Chile	0.052 (0.504)	0.052 (0.254)
	1990q3-2010q2	
Colombia	0.346** [2.157]	0.614** [4.577]
	1995q2-2010q2	
Mexico	-0.225** (-2.092)	-0.164 (0.876)
	1991q2-2010q2	
Peru	0.226*** (3.883)	0.569*** (51.928)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ which is not removed in the general to specific modelling process.

<u>Table 6.1</u>: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Other Emerging Market Economies(EMEs)-Europe, Middle East and Africa		
Czech Republic	0.052 (0.261)	0.226 (1.529)
	1997q2-2010q2	
Egypt	0.524*** [4.481]	0.013 [0.000]
	1990q2-2010q2	
Hungary	0.015 (0.239)	0.095 (0.890)
	1996q2-2010q2	
Israel	0.091 [0.704]	-0.164 [0.994]
	1991q2-2010q2	
Poland	0.007 (0.070)	1.211* (3.216)
	1998q1-2010q2	
Russia	0.292*** (5.938)	0.515*** (59.747)
	1996q2-2010q2	
South Africa	-0.020 (-0.076)	0.882** (6.060)
	1990q2-2010q2	
Turkey	-0.300*** [-3.093]	-0.214 [1.501]
	1995q1-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ which is not removed in the general to specific modelling process.

Table 6.1: Continued

Country	The effect of $\Delta \text{Real FXR}_{cb,t} / \text{Real BM}_{br,t-1}$ on $\Delta \text{Real BM}_{br,t} / \text{Real BM}_{br,t-1}$ (i) Contemporaneous α_{20}	(ii) Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Developed Economies		
Australia	0.081 (0.110)	0.172 (0.004)
	1991q2-2010q2	
Canada	0.371 (1.245)	1.883* (3.066)
	1991q2-2010q2	
Denmark	0.048 (0.491)	0.336** (5.334)
	1990q2-2010q2	
Japan	-0.455 [-1.239]	-0.409 [1.529]
	1991q2-2010q2	
New Zealand	0.233 (1.537)	0.496*** (12.851)
	1991q2-2010q2	
Norway	0.296*** {4.451}	1.039*** {40.475}
	1990q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta \text{Real FXR}_{cb,t} / \text{Real BM}_{br,t-1}$ which is not removed in the general to specific modelling process.

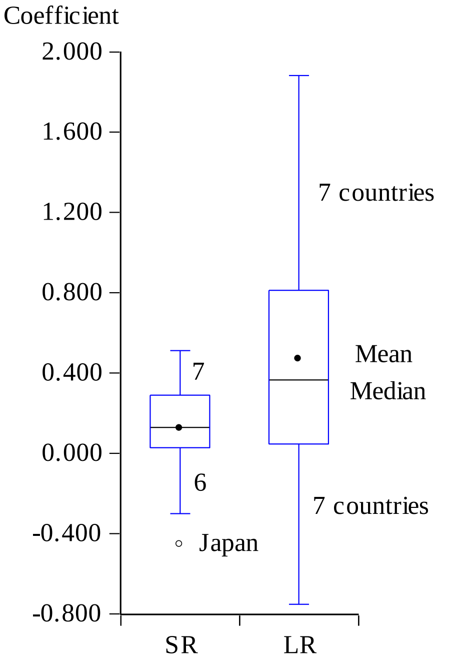
<u>Table 6.2</u>: Real Intervention Effects on Real Broad Money Change - Group Averages

Group	The group average effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4}\alpha_{2i} \Big/ (1 - \sum_{i=1}^{4}\alpha_{1i})$
Asia	0.207* (1.907)	1.184** (4.786)
Excluding Taiwan	*0.179* (1.673)*	*0.618** (5.306)*
Latin America	0.185** (2.381)	0.249*** (10.696)
Other EMEs	0.083* (1.883)	0.321*** (9.188)
Excluding Egypt	*0.020 (1.512)*	*0.364*** (10.501)*
Developed Economies	0.096 (1.512)	0.586*** (10.543)
TOTAL	**0.147* (1.834)**	**0.647*** (8.293)**
Excluding Taiwan and Egypt	***0.122* (1.662)***	***0.469*** (8.882)***
Sample standard deviation (excluding Taiwan and Egypt)	*0.219*	*0.636*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average t-statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4}\alpha_{2i}/(1-\sum_{i=1}^{4}\alpha_{1i}) = 0$.
- For both the t-and F- statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$which is not removed in the general to specific modelling process.
- Results are reported for average values which exclude Egypt and Taiwan. The former is an outlier in the analysis of intervention effects on real base money growth and the latter, and outlier in the analysis of intervention effects on real broad money growth.

The standard deviations across the sample group of 28 countries are 0.219 and 0.636 respectively for the short-run and long-run coefficients. We observe that the short-run coefficients are in the range of 0.000 – 0.300 for 16 countries and negative in value for five countries. With regard to the long-run coefficients, 18 countries fall in the range 0.000-0.800, whilst five countries display negative values. Nevertheless, the negative coefficients tend to be of smaller economic significance compared to the positive coefficients and most also lack statistical significance. A possible explanation for the negative coefficients is that sterilisation has taken place at the non-bank private sector level (rather than at the banks level) to an extent that exceeds the money supply shock associated with intervention. This may be part of a policy of monetary control that leads to interest rate increases, contraction in the real sector and a further reduction in broad money. The dispersions in the short-run and long-run coefficients across countries are summarised in the following boxplots (Graph 6.1). The long-run coefficients are noticeably more dispersed than the short-run coefficients, but both groups appear to be more evenly distributed compared to the results for the effects of real intervention on changes in base money (Graph 5.1 in Chapter 5).

<u>Graph 6.1</u>: Boxplots for the Short-run and Long-run Real Intervention Effects on Real Broad Money Change



Note: Box encloses middle 50% of the observations.

A comparison with the results of previous empirical work is hindered by the limited amount of existing research that has quantified the effects of intervention on changes in broad money. Thus, we are only able to make a quantitative evaluation of our results against those of Takagi (1999). In particular, we compare the average of the long-run coefficients for the subset of the countries[88] in our sample which is consistent with the sample used by Takagi, against the average of the author's estimated coefficients on the first-order lagged real intervention variables. Takagi's estimated coefficients are based on static multivariate regressions using quarterly data over the period 1987q1-1997q2. At 0.886, our result is strikingly in contrast to that of Takagi's at -0.009. Furthermore, on an individual-country basis, in Takagi's case, there is hardly any statistical significance of the coefficients, except in the case of the Philippines. One obvious difference between our study and Takagi's is the sample period under consideration, suggesting the importance of variations in the coefficients over time. However, it would appear that the methodology and data used also matter. With regard to the former, our dynamic model specification allows for

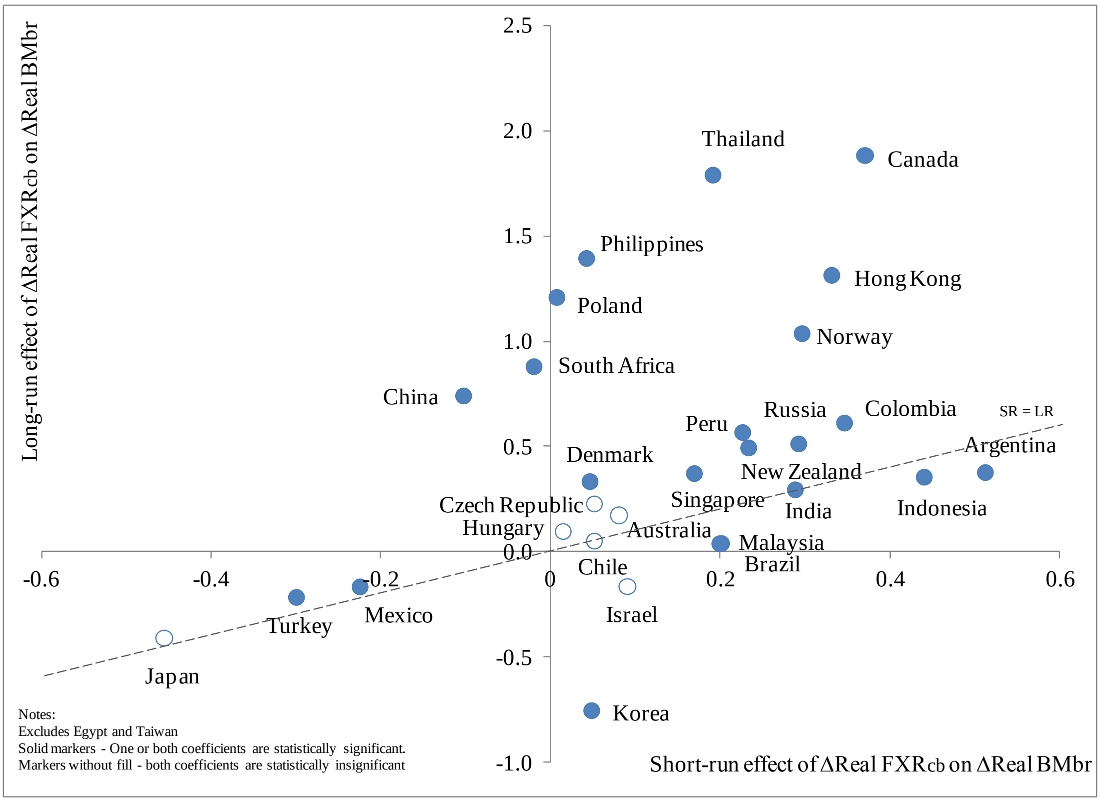
[88] The countries are Indonesia, Korea, Malaysia, Philippines and Thailand.

both the contemporaneous and indirect effects of intervention to be taken into account. Meanwhile, where data are concerned, we have generally used the broadest national monetary aggregate for each country rather than M1 and in some instances, M2.

While Cardarelli *et al*. (2009) do not report the results for the effects of a change in foreign assets on changes in broad money we can nevertheless conclude that our results are not similar to theirs. This is because they state that their results for the broad sterilisation measure are consistent with the narrow sterilisation measure, while in our study, there is evidence that the effects of real intervention on changes in real broad money differ from its effects on changes in real base money.

In Graph 6.2 we plot the long-run coefficients against the short-run coefficients for our sample of 28 countries and in Table 6.3 we provide the results of a regression between these two variables. Most countries are in the top right quadrant of the graph, implying positive short-run and long-run effects. A unit increase in the short-run coefficient leads to a 1.2 unit increase in the long-run coefficient. This effect is of similar economic significance compared to the relationship between the short-run and long-run effects of real intervention on changes in real base money as seen in Chapter 5, where a unit increase in the short-run coefficient leads to a 1.1 unit increase in the long-run coefficient (0.9, if excluding Israel and Japan). However, in contrast, the statistical significance and in particular, the explanatory power of the short-run coefficient as a regressor is lower compared to the relationship between the short-run and long-run effects of real intervention on changes in real base money. In Graph 6.2, we find that the data points tend to fall above the line of equality between the short-run and long-run coefficients, with long-run coefficients exceeding short-run coefficients. With reference to Diagram 4.5 in Chapter 4, this suggests that countries are generally in the top left quadrant of the diagram, exhibiting relatively strong credit creation driven intervention effects over time, notwithstanding small contemporaneous effects. As we discussed in Chapter 4, the unique contemporaneous effects may be small once control variables are taken into account, and may also be non-existent in the first instance if intervention is related to bank or government flows. However, the excess liquidity available to banks has increased regardless, and can lead to higher intervention effects in the long run. In contrast, with regard to the intervention effects on base money growth, the average short-run and long-run coefficients have been observed to be similar, with individual country coefficients generally falling in the bottom left and top right quadrants of Diagram 4.4. This is not surprising as, unless there is a marked shift in policy (in terms of interest rate-targeting or the use of reserve requirements) or in private sector behaviour (the demand for currency and excess reserves), the coefficients are not expected to differ significantly over time.

<u>Graph 6.2</u>: The Relationship between Short-run and Long-run Effects of Real Intervention on Real Broad Money Change



<u>Table 6.3</u>: Regression Analysis between Short-run and Long-run Effects of Real Intervention on Real Broad Money Change

	Dependent variable: Long-run Coefficient		
Regressor: Short-run Coefficient	**Coefficient**	**t-statistic**	**Adjusted R^2**
All countries	1.202	2.318**	0.14

Note: The maximum number of observations is 28. The group "all countries" excludes Egypt and Taiwan. The regression includes a constant term which is not shown for brevity.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

In Table 6.4, we compare the short-run effect of real intervention on changes in real broad money against the short-run effect on changes in real base money. We do the same for the long-run effects. For both comparisons, we split the countries into two groups based on the real intervention effect on changes in real broad money – countries with positive coefficients larger than the median value for the sample of 28 countries, and countries with coefficients smaller than the median value, which includes negative coefficients. The averages and medians for these two subgroups are then reported alongside the associated averages and medians for the coefficients on the real intervention effects on changes in real base money. We test for differences using the ANOVA F-test for mean equality and also the Mann-Whitney test for median (distribution) equality. We use the latter test since non-normality and non-homogenous variances in the distribution for the coefficients on the real intervention effects on changes in real base money render the use of the ANOVA F-test contentious.

We observe that countries with short-run and long-run coefficients above the full sample median value for the real intervention effect on changes in real broad money do not display a significant difference in terms of the effects on changes in real base money, compared to countries with coefficients below the median value. This is consistent with our hypothesis of disconnect between the effects of real intervention on changes in real broad money and changes in real base money respectively, and reinforces the importance of analysing the effects on changes in real broad money. For our sample of countries, low intervention effects on base money growth do not imply a similar result for broad money growth. At the same time, higher intervention effects on base money growth, partly on account of the use of required reserves, are also not associated with lower intervention effects on broad money growth. With the model in Chapter 3, we showed that base money can be relatively steady regardless of the sector from which liquidity is absorbed using market-based sterilisation instruments. This, however, does not imply that broad money is similarly stable. Our finding that long-run intervention effects on broad money growth are economically significant and noticeably different from that on base money growth provides an empirical counterpart to the policy concerns that surround broad money sterilisation in the theoretical model.

Table 6.4: Real Intervention Effects: A Comparison between Real Broad Money Change and Real Base Money Change

Country Subgroups	Short-run Effect of Real Intervention – Average [Median]: Real Broad Money	Short-run Effect of Real Intervention – Average [Median]: Real Base Money	Long-run Effect of Real Intervention – Average [Median]: Real Broad Money	Long-run Effect of Real Intervention – Average [Median]: Real Base Money
Real intervention effect on changes in real broad money > median value	0.293*** [0.290]	0.074* [0.038]	0.944*** [0.813]	0.114*** [0.099]
Observations	14		14	
Real intervention effect on changes in real broad money < median value	-0.048 [0.029]	0.076* [0.008]	-0.006* [0.047]	0.109*** [0.021]
Observations	14		14	
Mean Equality: ANOVA F-test statistic		0.001		0.004
Median Equality: Mann-Whitney test statistic		0.850		1.103

Correlation coefficient (t-statistic)	
Short-run effects	-0.088 (-0.450)
Long-run effects	-0.218 (-1.144)

The first and third rows report the average short-run and long-run coefficients, and the median coefficient in brackets, for each subgroup. The statistical significance of the average values is based on the associated average t-and F-statistics. Countries are split into two subgroups based on the coefficients on the real intervention effect on changes in real broad money.
Test statistics are only reported for the test of group differences in terms of the real intervention effects on changes in real base money. The group differences in terms of the average and median coefficients for the real intervention effects on changes in real broad money are statistically significant by construction.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

6.2.2 Tests for the Relevance of Differences in Country Characteristics

In the previous section, we observed that the effects of real intervention on changes in broad money are relatively higher than and, as subgroup tests of equality indicate, disconnected from the effects of real intervention on changes in real base money. Nevertheless, the effects of real intervention on changes in real broad money are, on their own, considerably low as well, averaging 0.122 and 0.469 in the short run and long run respectively. This is notwithstanding several exceptions on an individual country basis of long-run coefficients exceeding 1.000.

In Chapter 4, we discussed various factors that can influence the nature of real intervention effects on changes in real broad money. As in section 5.2.2 of Chapter 5, in this section we evaluate the relevance of differences in country characteristics. The empirical methods and country characteristics considered are the same as those used in Chapter 5. In subsection 6.2.2.1 (Table 6.5), we test for differences in the coefficients for real intervention effects among the countries in our sample by splitting them into clearly delineated groups based on regions, current account and capital account balances (surpluses versus deficits), income levels (high income versus middle income) and monetary policy frameworks (inflation-targeting versus non-inflation-targeting). In subsection 6.2.2.2 (Tables 6.6(a) and 6.6(b)), we test for differences in some of these characteristics as well as other characteristics with less clear delineations, for subgroups of coefficients that fall into the boxplot quartile divisions as seen in Graph 6.1. In subsection 6.2.2.3, we carry out bivariate regressions with the coefficients on real intervention effects as the dependent variable, and each country characteristic, in turn, as the regressor.

We hypothesise that if there is a high degree of intervention and reserve accumulation, scaled by the size of the economy, the more likely it is that we will observe prominent effects on changes in real broad money. In particular, sustained current account and capital account surpluses, more so if occurring simultaneously, may be associated with relatively significant positive indirect effects of real intervention on changes in real broad money, since the banking system is flush with liquidity. Thus, it could be that the net balances on these accounts that matter more than trade and financial openness, even if the latter reflects an economy's reliance on the external sector.

These effects, however, may be complicated by several factors. Not all balance of payments flows involve intervention – the effects of balance of payments flows can be viewed as a distinct phenomenon from the effects of intervention. When intervention does occur, it matters how the central bank chooses to sterilise its operations, whether at the level of the private sector or at the level of the banking system. Furthermore, the use of foreign exchange swaps subsequent to intervention breaks the link between the timing of intervention and its effects on changes in broad money. Meanwhile, the effect of reserve requirement adjustments is unclear, particularly if these changes merely represent an alternative to open market operations in an interest rate-targeting framework. Naturally, indirect effects of external sector surpluses may be limited by policy tightening, but we propose that the distinction between inflation-targeting and non-inflation-targeting countries does not matter, unless there is no independent monetary policy in the latter case. Similarly, it is not necessarily the case that countries with less flexible exchange rates will exhibit higher intervention effects on changes in broad money.

The level of economic and financial development also matters: a high level of development may render the indirect effects of intervention limited on an already large money stock but at the same time may facilitate the intermediation process and potentially lead to greater intervention effects on changes in broad money. Higher income countries may also exhibit higher coefficients since these could reflect the stronger influence of financial factors relative to real sector factors, and the complexity of which may not be fully captured by the control variables.

The end result is that the immediate effects and the dynamics of the indirect effects of real intervention on changes in real broad money may be very much country-specific. This seems to be the scenario suggested by the results in the following three subsections.

6.2.2.1 Equality Tests for Differences in Coefficients on Real Intervention Effects between Groups of Countries

Observing column 2 of Table 6.5, we note differences in economic size and variations in statistical significance for the average short-run coefficients across the subgroups of all the categories except the monetary policy framework category. There are less obvious differences for the average long-run coefficients (column 4 of Table 6.5) across the subgroups of the categories. Based on the results of ANOVA F-tests,[89] however, we find no statistical significance for the differences observed across the means of the subgroups under consideration, indicating the strong dispersion of values within subgroups. The difference in coefficients between groups that comes closest to statistical significance is that between current account surpluses and deficits, and in terms of the short-run coefficient only (row 2 of Table 6.5). Furthermore, whilst there was some indication of difference between inflation-targeting and non-inflation-targeting countries in terms of the real intervention effects on changes in real base money, as seen in Chapter 5, we find no similar difference in the context of the real intervention effects on changes in real broad money (row 5 of Table 6.5).

[89] The distributions for the short-run and long-run coefficients were pre-tested for non-normality and homogenous variances across subgroups based on the subgroup classifications. We did not find any evidence of non-normality or heterogeneous variances.

<u>Table 6.5</u>: Mean Equality Tests for Real Intervention Effects on Real Broad Money Change

Groups	The effect of $\Delta\mathbf{Real\ FXR_{cb,t}/Real\ BM_{br,t-1}}$ on $\Delta\mathbf{Real\ BM_{br,t}/Real\ BM_{br,t-1}}$			
	Short-run Coefficient		**Long-run Coefficient**	
	Group Mean	**ANOVA F-statistic**	**Group Mean**	**ANOVA F-statistic**
1. **Region**				
Asia	0.179*	0.895	0.618**	0.508
Latin America	0.185**		0.249***	
Other EMEs	0.020		0.364***	
Developed Economies	0.096		0.586***	
2. **Current Account (CA) Balance**				
CA surplus	0.180**	1.721	0.586***	0.817
CA deficit	0.072		0.367**	
3. **Capital Account (KA) Balance**				
KA surplus	0.105	0.415	0.478**	0.013
KA deficit	0.165***		0.446***	
4. **Income Level**				
High income	0.099	0.272	0.448***	0.025
Middle income	0.143**		0.487***	
5. **Monetary Policy Framework**				
Inflation targeting	0.113	0.107	0.502***	0.153
Non-inflation-targeting	0.142		0.390***	

CA and KA surpluses are measured based on the number of surplus years as a proportion of the total number of years corresponding to the regression sample period for each country. A country is recorded as a surplus country if the proportion exceeds 0.5.
Income level is measured by the average of GDP per capita based on purchasing power parity over the regression sample period for each country. Countries are classified as either high or middle income based on the World Bank income classification scheme.
Inflation-targeting countries are countries that have adopted the inflation-targeting framework at some point during our sample period.
All groups exclude Egypt and Taiwan.
Short-run and long-run average statistical significance of the coefficients for subgroups in the "Group Mean" columns are based on the corresponding simple average of t- and F-statistics. These do not indicate statistically significant differences across the subgroups.
The mean equality test is the single-factor ANOVA F-test.
***significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

6.2.1.2 *Equality Tests for Differences in Country Characteristics based on Differences in Real Intervention Effects*

In Tables 6.6(a) and 6.6(b) we perform equality tests of characteristics of countries grouped by the boxplot quartiles for the short-run and long-run effects of real intervention on changes in broad money as seen in Graph 6.1.[90] As in Table 6.5, the characteristics include the number of surplus years on the current account and capital account, and income levels. Additionally, we also consider the current account and capital account average balances, scaled by GDP; the balance positions and surplus years for subcomponents of the capital account – the sum of net direct investment and portfolio investment, and net other investment balances respectively; current account and capital account openness; intervention indicators – volatility, reserve accumulation, and the number of surplus periods; and exchange rate flexibility.

The ANOVA F-test for mean equality is carried out when the distribution of the characteristic exhibits normality,[91] while the Kruskal-Wallis test for median equality is used when there is evidence of non-normality. For the different quartile groups of short-run real intervention effects on changes in real broad money (Table 6.6(a)), we observe statistically significant differences in the capital account balance and its subcomponent, net direct investment and portfolio investment balance. The values are observed to monotonically decrease with higher averages of the intervention coefficients. There is also some mixed indication of statistically significant differences in the current account balance,[92] which are monotonically consistent with the differences in the capital account balance. This is not surprising given the balance of payments identity. The results suggest that higher short-run coefficients appear to be associated with capital account deficits, and lower balances

[90] The number of countries in each quartile beginning with the upper quartile is as follows: 7, 14, and 7 respectively, for both the short-run and long-run coefficients.

[91] There is some indication of heterogeneous variances across subgroups in the income levels category in Tables 6.6(a) and 6.6(b) and in the category of surplus years for net direct investment and portfolio investment balance in Table 6.6(b). The results of the Welch F-test, which allows for unequal variances, do not, however, suggest different conclusions from the ANOVA F-test.

[92] Note from Table 6.6(a), item 2, there are only statistically significant differences in terms of the average balance but not the surplus years. We also tested for differences in cumulative balances – the sum of the annual net position in the account, scaled by the average annual nominal GDP, for the years that correspond to the regression sample period. We do this for the current account, the capital account, and the latter's subcomponents. The results for the equality tests differed from those for the average balances only in the case of the current account balance, with no statistically significant differences found in terms of the cumulative balances.

in the subcomponent, net direct investment and portfolio investment; as well as, correspondingly, current account surpluses.

Meanwhile, for the different quartile groups of long-run real intervention effects on changes in real broad money (Table 6.6(b)), based on the equality tests, there are no statistically significant differences in any of the corresponding characteristics. In particular, statistically significant differences are neither apparent in the balance of payment surpluses, nor in the intervention indicators.

<u>Table 6.6(a)</u>: Equality Tests of Country Characteristics Grouped by Boxplot Quartiles of Short-run Intervention Effects on Broad Money Change

	Country Characteristic	Subgroup Average/[Median] of Characteristic			Equality Test Statistic
		Upper quartile	Inter-quartile	Lower quartile	
1.	Openness				
	Current account	[0.642]	[0.846]	[0.587]	1.471
	Capital account	[0.166]	[0.166]	[0.113]	1.428
2.	Current Account Balance				
	Surplus years	0.707	0.427	0.363	2.017
	Average balance	[3.436]	[-0.062]	[-2.397]	4.747*
3.	Capital Account Balance				
	Surplus years	0.434	0.733	0.776	3.503**
	Average balance	[-0.313]	[2.130]	[3.380]	7.230**
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years	0.537	0.794	0.804	2.728*
	Average balance	[0.172]	[2.155]	[2.731]	5.152*
5.	Net Other Investment Balance				
	Surplus years	0.381	0.507	0.548	1.178
	Average balance	[-0.291]	[0.351]	[0.340]	1.808
6.	Intervention Indicators				
	Volatility	[0.538]	[0.684]	[0.416]	1.808
	Reserve accumulation	[0.144]	[0.328]	[0.203]	3.001
	Surplus quarters	[0.583]	[0.621]	[0.673]	1.907
7.	Income Level	19.146	15.317	12.186	0.709
8.	Exchange Rate Flexibility	8.485	9.048	10.887	1.644
Note:					
Corresponding subgroup average of short-run real intervention effects		0.370***	0.137	-0.154	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the boxplot quartiles of intervention effects in Graph 6.1.
The mean equality test is the single-factor ANOVA F-test.
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

Table 6.6(b): Equality Tests of Country Characteristics Grouped by Boxplot Quartiles of Long-run Intervention Effects on Broad Money Change

	Country Characteristic	Subgroup Average/[Median] of Characteristic			Equality Test Statistic
		Upper quartile	Inter-quartile	Lower quartile	
1.	Openness				
	Current account	[0.885]	[0.640]	[0.587]	3.553
	Capital account	[0.147]	[0.169]	[0.117]	2.087
2.	Current Account Balance				
	Surplus years	0.562	0.455	0.453	0.217
	Average balance	[0.279]	[-0.681]	[-0.060]	0.626
3.	Capital Account Balance				
	Surplus years	0.566	0.720	0.670	0.607
	Average balance	[1.764]	[2.685]	[1.400]	1.023
4.	Net Direct Investment and Portfolio Investment Balance				
	Surplus years	0.630	0.799	0.701	0.954
	Average balance	[2.456]	[2.522]	[0.752]	1.543
5.	Net Other Investment Balance				
	Surplus years	0.509	0.476	0.482	0.053
	Average balance	[0.435]	[0.064]	[-0.134]	1.628
6.	Intervention Indicators				
	Volatility	[0.712]	[0.721]	[0.490]	1.791
	Reserve accumulation	[0.203]	[0.274]	[0.211]	0.057
	Surplus quarters	[0.636]	[0.594]	[0.680]	3.446
7.	Income Level	18.908	14.119	14.820	0.452
8.	Exchange Rate Flexibility	9.324	8.989	10.167	0.424
Note:					
Corresponding subgroup average of long-run real intervention effects		1.360***	0.373***	-0.231	

For each subgroup of countries, either the average or median (in square brackets) of the characteristic is shown.
The countries are divided into the subgroups based on the boxplot quartiles of intervention effects in Graph 6.1.
The mean equality test is the single-factor ANOVA F-test.
The median equality test is the Kruskal-Wallis test, which is used when non-normality is detected in the series.
Differences in mean/median: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Explanatory notes on country characteristics (unless otherwise indicated, all variables are measured in US dollars):

1. Openness is measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.
2. The total surplus years is measured by the number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. The values are between 0 and 1.
   The average balance is the average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100.
3. The capital account includes net errors and omissions. Surplus years and average balance are defined as in 2.
4. Net direct investment and portfolio investment are subaccounts of the capital account. Surplus years and average balance are defined as in 2 and are for the sum of the two accounts.
5. Net other investment is a subaccount of the capital account. It excludes official other investment which involves the government or monetary authorities. Surplus years and average balance are defined as in 2.
6. Intervention volatility is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation is the sum of change in foreign exchange reserves over the regression sample period, scaled by the average annual nominal GDP. The total surplus quarters refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters that corresponds to the regression sample period. The values are between 0 and 1.
7. GDP per capita based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period.
8. Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.

6.2.2.3 *Regression Analysis between Coefficients on Real Intervention Effects and Country Characteristics*

In this subsection, we assess if there exist linear relationships between real intervention effects on changes in real broad money and specific country characteristics. We treat the estimated coefficients for real intervention effects in the real broad money equation for each country as the dependent variable and investigate whether these coefficients vary systematically with income levels; the nature of intervention (volatility, the number of surplus periods, and reserve accumulation); exchange rate flexibility; and the nature of the current and capital accounts in terms of openness and net balances. The bivariate regression specification is as follows:

$$y_i = \alpha + \beta x_i \tag{6.3}$$

where
i =country
y= short-run/long-run coefficient on real intervention effect
x= country characteristic

Our hypotheses about the relationships between the country characteristics and real intervention effects were discussed at the beginning of Section 6.2.2. Here we summarise our reasons for choosing these variables. Amongst the intervention indicators, volatility points to the size of intervention activity and we expect that this may have a positive relationship with real intervention effects on changes in broad money, particularly in the short run, although the nature of balance of payments flows and sterilisation may weaken such a link. Surplus periods and reserve accumulation, the latter including scale effect, are meant to assess if the distinction between surpluses and deficits matter, particularly for long-run indirect effects. In terms of the balance of payments subcomponents, we make a distinction between net balance and openness to separately evaluate the significance of the type of balance of payments surplus or deficit; and the importance of the size and volatility of external flows for each economy. Exchange rate flexibility is a unique characteristic in that it reflects the confluence of exchange rate regime/monetary policy framework, balance of payments shocks and intervention. We would expect that it has a negative relationship with intervention effects on changes in broad money to the extent that it is closely linked with intervention and captures the potentially looser control over intervention effects that may be associated with hard peg regimes. Meanwhile, as mentioned earlier on, our expectation of the relationship between income levels and intervention effects could be positive or negative.

Before we discuss the results of the regression analysis, in Table 6.7, we present unconditional correlation coefficients between the coefficients on intervention effects and selected country characteristics, as well as between the characteristics themselves. The description of the measurement of each characteristic is provided in the notes to the table.[93] We find that the short-run coefficient for real intervention effects on changes in real broad money only has statistically significant but economically small negative correlations with surplus periods and exchange rate flexibility. While the latter result is not surprising, the former seems counterintuitive, especially since surplus periods appear to be related to current account surpluses, which we expect, ceteris paribus, would translate into broad money increases. However, it could be that given we have, to some extent, controlled for income effects on broad money changes, the unique effect of intervention related to current account surpluses is less apparent. Furthermore, as mentioned, the measure of surplus periods lacks a size element, and also captures capital account surpluses. It is worth noting that the results in both instances, surplus periods and exchange rate flexibility, are likely influenced by outlier countries – China and Japan[94], and Hong Kong and Japan[95], respectively. On the basis of the t-statistics for the correlations between the short-run coefficient and other characteristics, the next strongest links are the positive correlations with intervention volatility and the current account balance, the latter matched by a corresponding negative correlation with the capital account balance.

[93] A similar table, Table 5.6, was presented in Chapter 5. Some of the correlation coefficients between the same characteristics may show minor differences in size (but not in direction and statistical significance) on account of small differences in sample sizes. A brief discussion on the correlations between the characteristics is contained in Section 5.2.2.3 of Chapter 5.

[94] Both countries have high proportions of surplus periods but negative short-run coefficients.

[95] Hong Kong has very low exchange rate flexibility and a positive short-run coefficient. Japan has high exchange rate flexibility and a large negative short-run coefficient.

Meanwhile, the long-run coefficient does not appear to have statistically significant correlations with any of the characteristics. The relatively strongest links, based on the t-statistics, are the negative correlation with exchange rate flexibility and the positive correlations with both, current account and capital account openness.[96]

[96] Upon consideration of the surplus years for the current account, capital account, net direct and portfolio investment balances and other investment balances; as well as the average balances for the latter two variables, we find a weakly statistically significant (at the 10% level) negative correlation between the number of surplus years in the net other investment balances with the short-run coefficient on real intervention effect (-0.316).

<u>Table 6.7</u>: Correlation Coefficients (with t-statistics) for Real Intervention Effects on Real Broad Money Change and Selected Country Characteristics

	Short-run coefficient (SR)	LR	Y/c	FXIV	FXIS	RA	ERF	CAO	KAO	CAB
Long-run coefficient (LR)	0.414** (2.318)									
GDP per capita (Y/c)	0.014 (0.073)	0.049 (0.249)								
Intervention volatility (FXIV)	0.264 (1.398)	0.182 (0.943)	0.358* (1.957)							
Proportion of time with positive intervention (FXIS)	-0.347* (-1.889)	-0.031 (-0.160)	-0.117 (-0.599)	0.198 (1.029)						
Reserve accumulation (RA)	0.007 (0.038)	0.136 (0.701)	0.096 (0.492)	0.691*** (4.877)	0.686*** (4.804)					
Exchange rate flexibility (ERF)	-0.357* (-1.947)	-0.206 (-1.075)	0.013 (0.068)	-0.546*** (-3.323)	-0.064 (-0.329)	-0.427** (-2.409)				
Current account openness (CAO)	0.157 (0.813)	0.197 (1.025)	0.474*** (2.744)	0.816*** (7.206)	0.236 (1.237)	0.713*** (5.191)	-0.413** (-2.315)			
Capital account openness (KAO)	0.181 (0.940)	0.220 (1.147)	0.610*** (3.930)	0.836*** (7.754)	0.065 (0.334)	0.508*** (3.007)	-0.427** (-2.410)	0.866*** (8.813)		
Current account balance (CAB)	0.207 (1.077)	0.115 (0.592)	0.394** (2.186)	0.641*** (4.258)	0.434** (2.460)	0.708*** (5.117)	-0.247 (-1.298)	0.612*** (3.949)	0.492*** (2.885)	
Capital account balance (KAB)	-0.239 (-1.255)	-0.087 (-0.446)	-0.443** (-2.519)	-0.419** (-2.356)	-0.125 (-0.640)	-0.266 (-1.405)	0.147 (0.760)	-0.273 (-1.448)	-0.295 (-1.572)	-0.841*** (-7.923)

- Y/c is the measure of the annual average of GDP per capita based on purchasing power parity (millions of current international dollar) over the regression sample period.
- FXIV is measured by the standard deviation of the monthly changes in foreign exchange reserves (in US dollar), scaled by the average annual nominal GDP (in US dollar).
- FXIS is measured by the number of quarters with a positive increase in reserves as a proportion of the total number of quarters in the regression sample period. The values are between 0 and 1.
- RA is the sum of change in foreign exchange reserves (in US dollar) scaled by the average annual nominal GDP (in US dollar).
- ERF is identified based on the historical *de facto* fine classification provided by Ilzetzki et al. (2011) which updates the analysis by Reinhart and Rogoff (2002). Essentially, each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.
- CAO and KAO are measured as the average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP. CA, KA and GDP are in nominal US dollars. The KA also includes net errors and omissions.
- CAB and KAB are measured as the average of the annual net position in each account scaled by the average annual GDP for the years that correspond to the regression sample period.
- ***significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

In Tables 6.8 and 6.9, we present the results of bivariate regressions between the short-run and long-run coefficients on intervention effects, with the selected country characteristics as listed in Table 6.7, and with the balances and surplus years for the capital account subcomponents. Consistent with the correlation coefficients presented in Table 6.7, we find statistically significant negative relationships between the short-run coefficient with surplus periods (FXIS) and exchange rate flexibility (ERF) respectively. Additionally, the short-run coefficient is negatively related to the proportion of surplus years recorded for net other investment balances (OIS). There are no other statistically significant linear relationships between the short-run and long-run coefficients with the country characteristics. However, similar to our correlation analysis in Table 6.7, we note on the basis of the t-statistics for the rest of the country characteristics, that the short-run coefficient's next strongest links are with the current account and capital account balances; while in the case of the long-run coefficient, the strongest links are with exchange rate flexibility, and current account and capital account openness. We also observe that the signs on the coefficients of the regressors are consistent between the respective bivariate regressions for the short-run and long-run intervention coefficients, with the exception of the net other investment balance (OIB) which has a positive, albeit statistically insignificant, relationship with the long-run intervention effect. Plots of the coefficients against the various country characteristics are presented in Graphs 6.3 and 6.4. From most of the plots, we note that there is very little indication of linear or discernible non-linear relationships between the coefficients and the characteristics. There appears be a quadratic relationship between per capita income and the long-run coefficient (Graph 6.4) which is also reflected in the RESET failure of the linear bivariate regression (Table 6.9).

Table 6.8: Bivariate Regressions between Short-run Real Intervention Effects on Real Broad Money Change and Country Characteristics

Country Characteristic (Regressor in bivariate regression)		Dependent Variable: Short-run Effect of $\Delta \mathbf{Real\ FXR_{cb,t}/Real\ BM_{br,t-1}}$ on $\Delta \mathbf{Real\ BM_{br,t}/Real\ BM_{br,t-1}}$			
		Coefficient	**t-statistic**	**Adjusted R^2**	**Diagnostics**
1.	GDP per capita (Y/c)	0.290	0.073	-0.04	
2.	Intervention volatility (FXIV)	0.090	1.398	0.03	Heteroscedasticity**
3.	Surplus periods (FXIS)	-0.696	-1.890*	0.09	
4.	Reserve accumulation (RA)	0.004	0.038	-0.04	
5.	Exchange rate flexibility (ERF)	-0.029	-1.947*	0.09	
6.	Current account openness (CAO)	0.035	0.813	-0.01	Heteroscedasticity*
7.	Capital account openness (KAO)	0.143	0.940	-0.00	
8.	Current account balance (CAB)	0.820	1.077	0.01	
9.	Current account surplus years (CAS)	0.088	0.750	-0.02	
10.	Capital account balance (KAB)	-1.371	-1.255	0.02	Non-normality*
11.	Capital account surplus years (KAS)	-0.114	-0.802	-0.01	Non-normality*
12.	Net direct and portfolio investment balance (DIPIB)	-1.079	-0.933	-0.00	
13.	Net direct and portfolio investment balance surplus years (DIPIS)	-0.053	-0.338	-0.03	
14.	Net other investment balance (OIB)	-0.657	-0.629	-0.02	
15.	Net other investment balance surplus years (OIS)	-0.318	-1.697*	0.07	

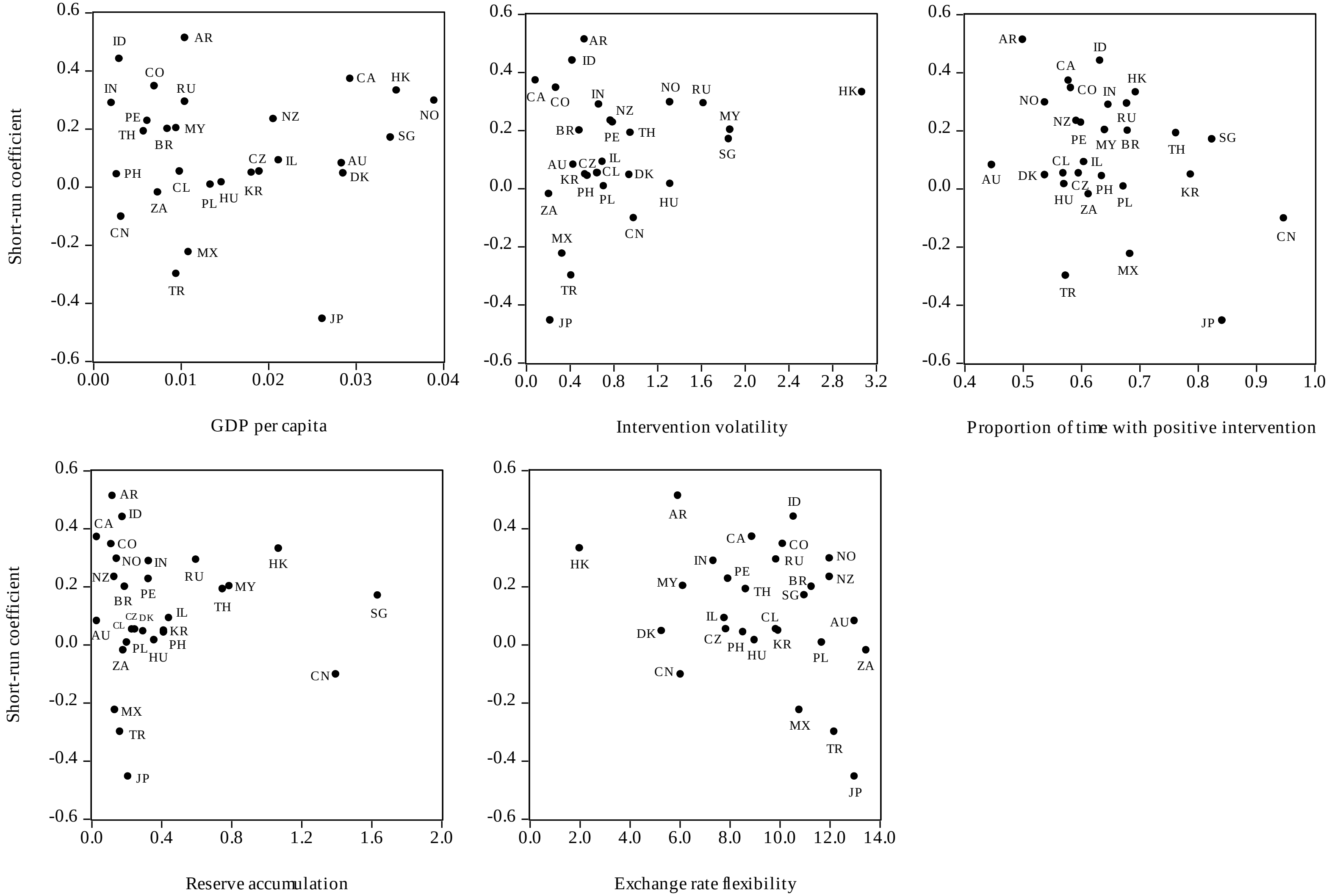
All regressions include a constant which is not shown for brevity.
For the t-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
See the notes to Tables 6.6(a) and (b), and Table 6.7 for descriptions of the respective regressors.

Table 6.9: Bivariate Regressions between Long-run Real Intervention Effects on Real Broad Money Change and Country Characteristics

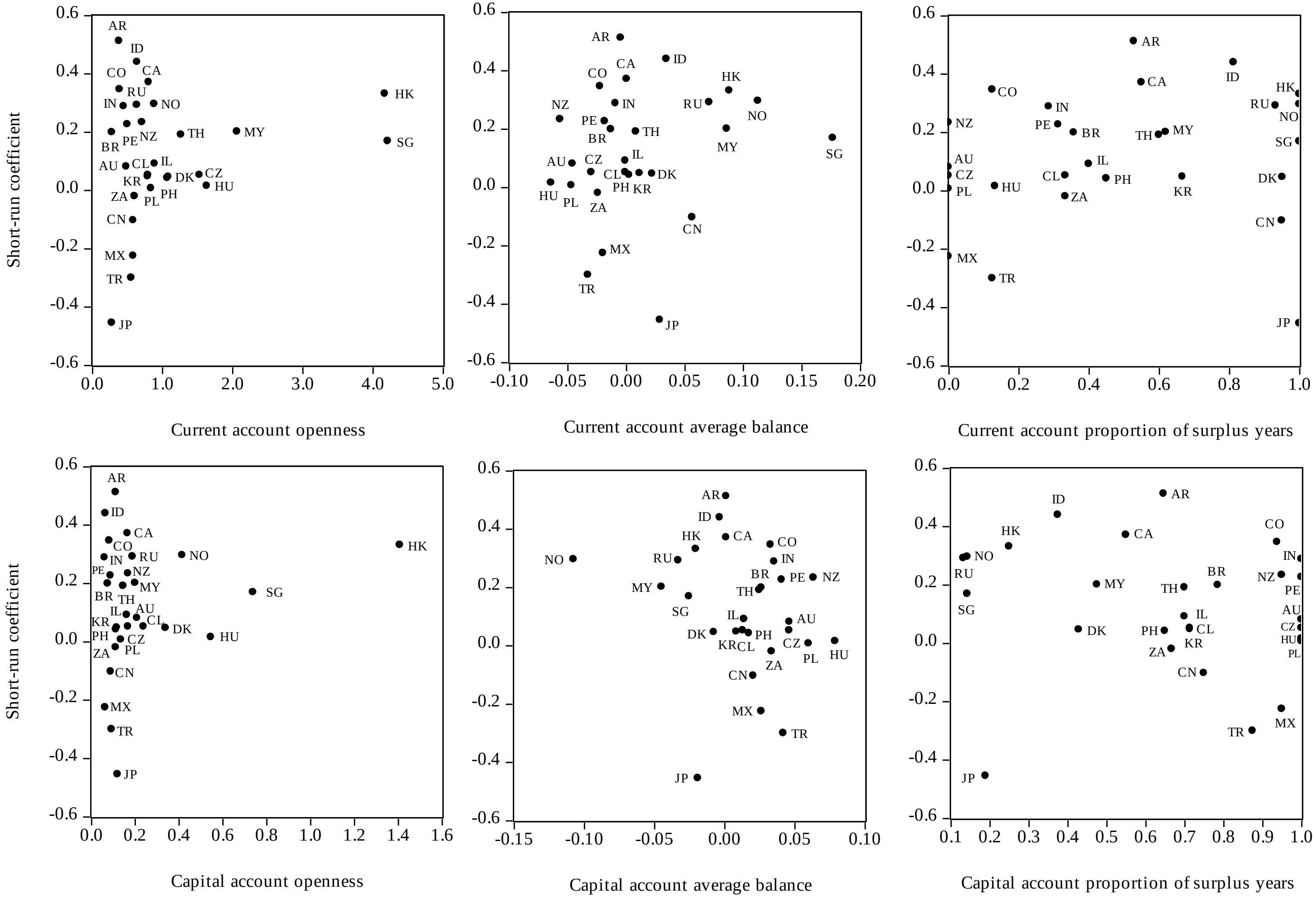
Country Characteristic (Regressor in bivariate regression)		Dependent Variable: Long-run Effect of $\Delta \text{Real FXR}_{cb,t} / \text{Real BM}_{br,t-1}$ on $\Delta \text{Real BM}_{br,t} / \text{Real BM}_{br,t-1}$ Coefficient	t-statistic	Adjusted R^2	Diagnostics
1.	GDP per capita (Y/c)	2.852	0.249	-0.04	RESET failure**
2.	Intervention volatility (FXIV)	0.180	0.943	-0.00	
3.	Surplus periods (FXIS)	-0.182	-0.160	-0.04	
4.	Reserve accumulation (RA)	0.218	0.701	-0.02	
5.	Exchange rate flexibility (ERF)	-0.048	-1.075	0.01	
6.	Current account openness (CAO)	0.128	1.025	0.00	
7.	Capital account openness (KAO)	0.503	1.148	0.01	
8.	Current account balance (CAB)	1.325	0.590	-0.02	
9.	Current account surplus years (CAS)	0.239	0.704	-0.02	
10.	Capital account balance (KAB)	-1.442	-0.443	-0.03	
11.	Capital account surplus years (KAS)	-0.283	-0.683	-0.02	
12.	Net direct and portfolio investment balance (DIPIB)	-2.993	-0.889	-0.01	
13.	Net direct and portfolio investment balance surplus years (DIPIS)	-0.170	-0.373	-0.03	
14.	Net other investment balance (OIB)	0.742	0.243	-0.04	
15.	Net other investment balance surplus years (OIS)	-0.281	-0.491	-0.03	

All regressions include a constant which is not shown for brevity.
For the t-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
See the notes to Tables 6.6(a) and (b), and Table 6.7 for descriptions of the respective regressors.

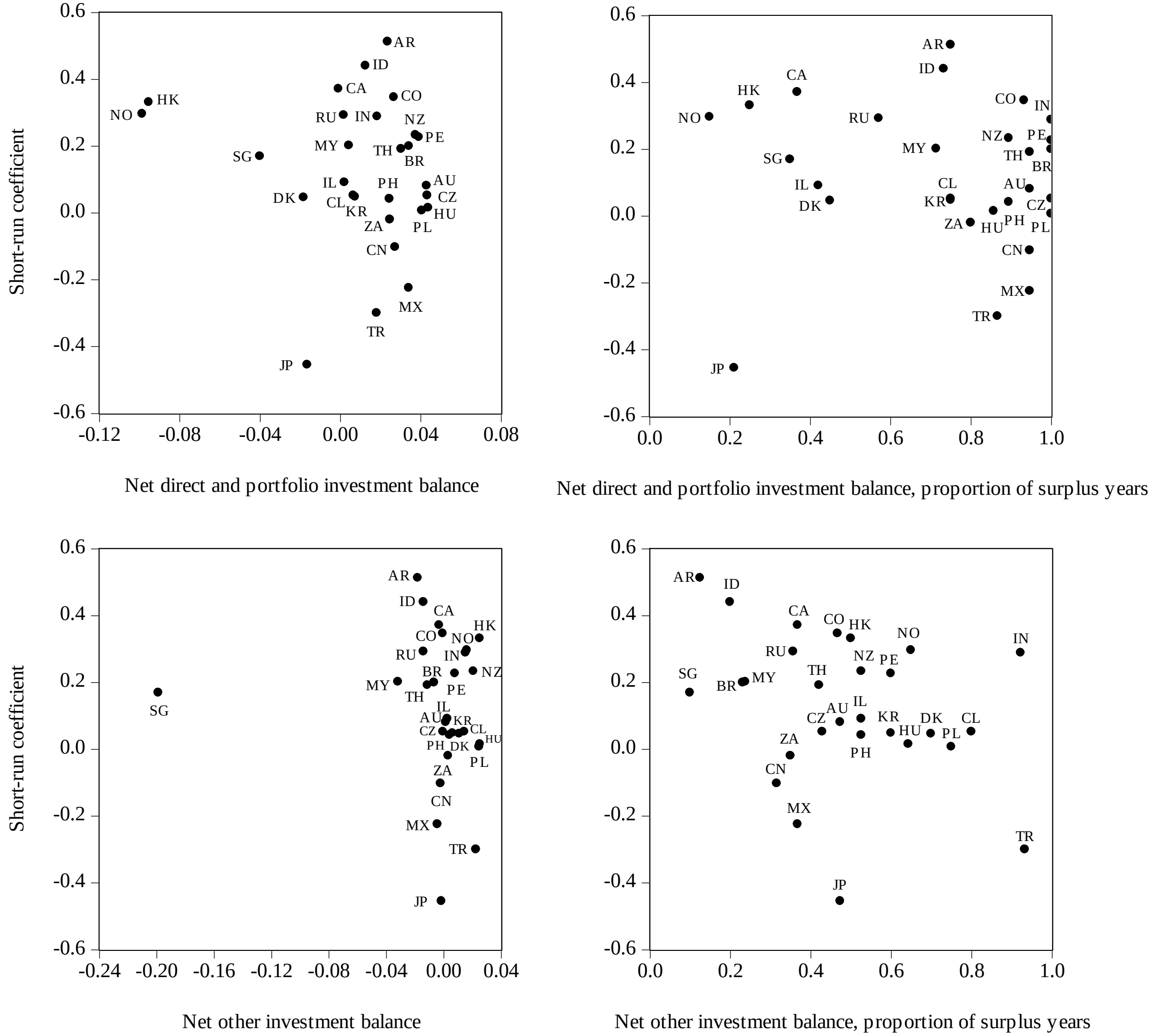
Graph 6.3: Short-run Real Intervention Effects on Real Broad Money Change and Country Characteristics



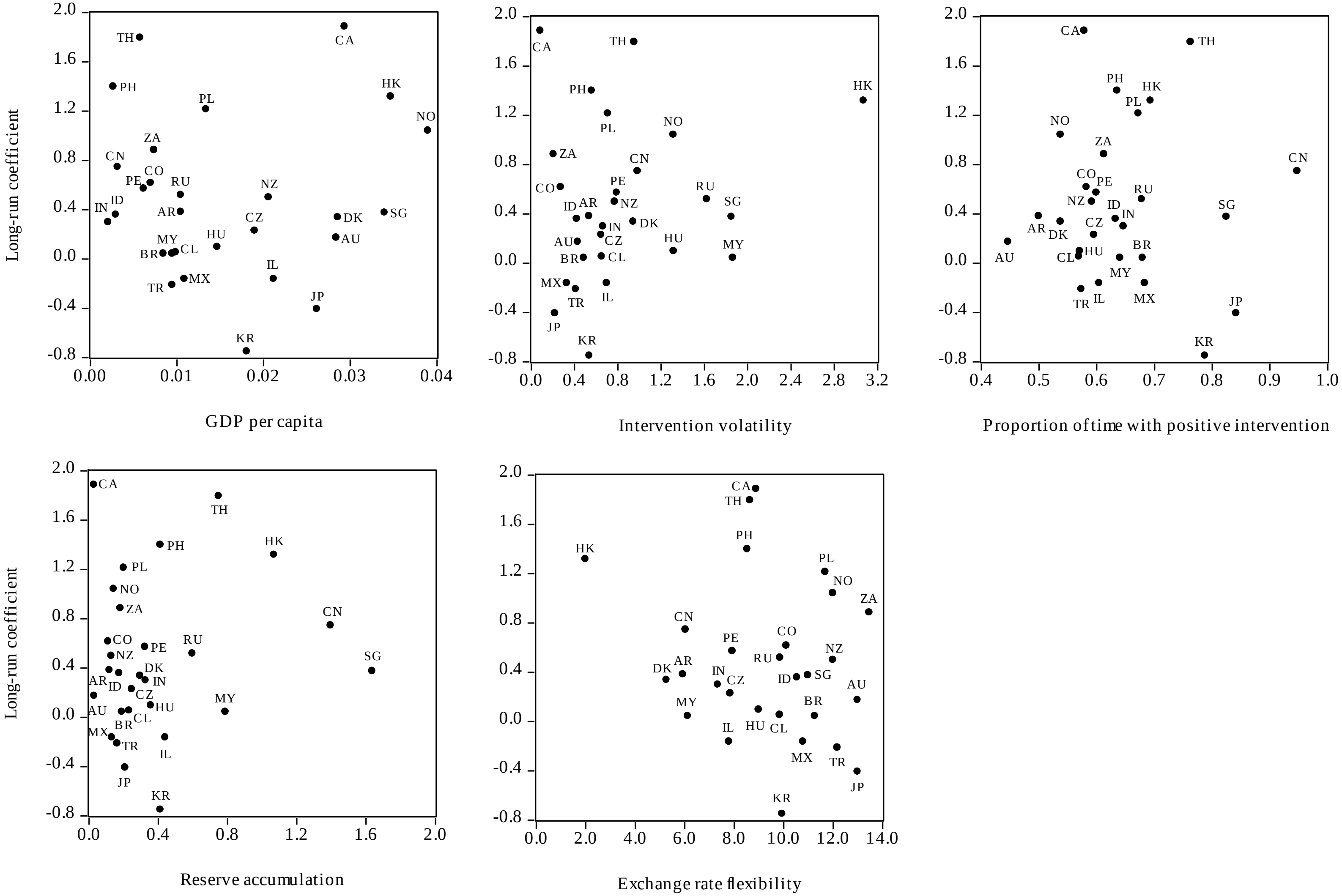
Graph 6.3: Continued



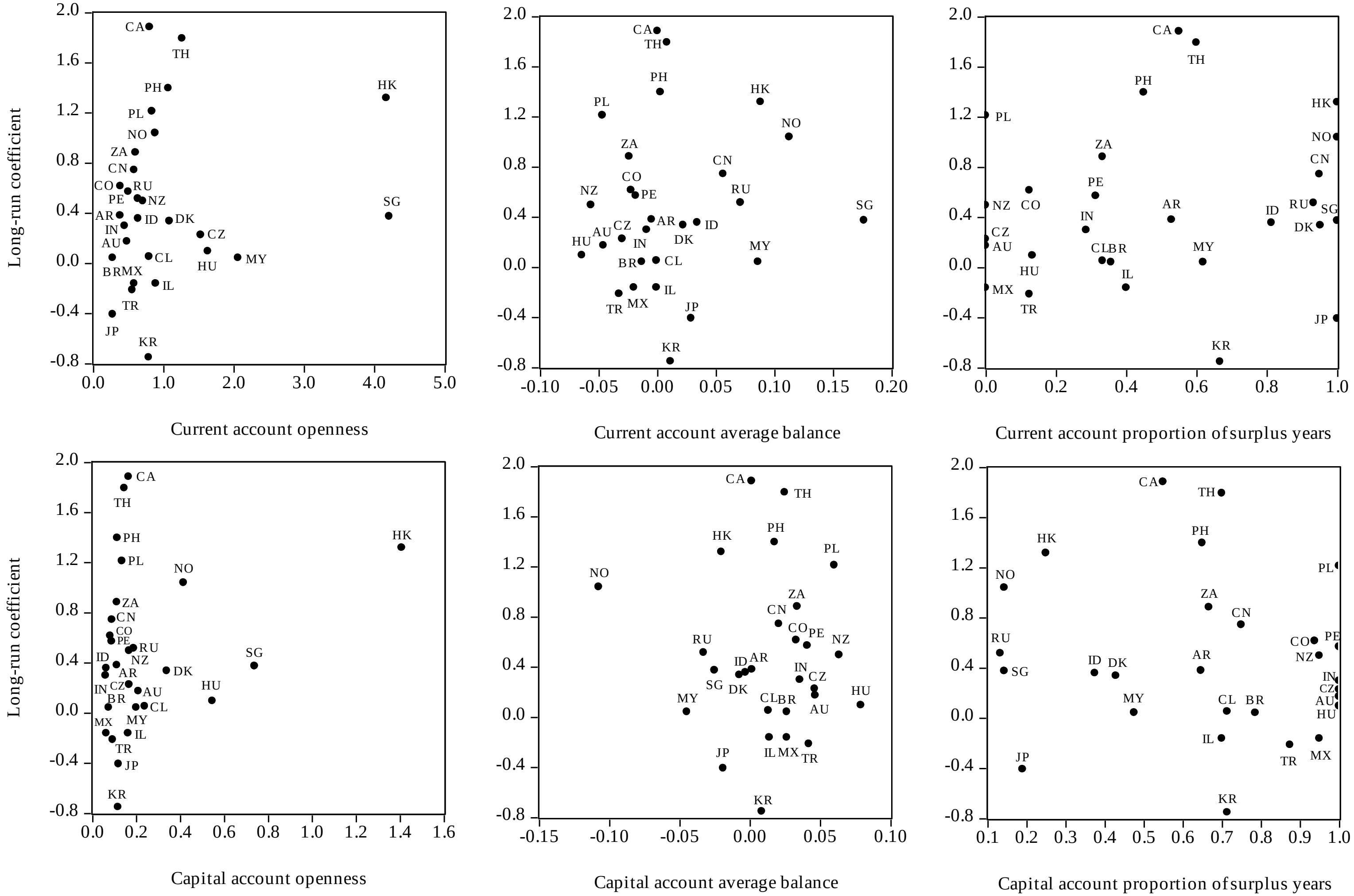
Graph 6.3: Continued



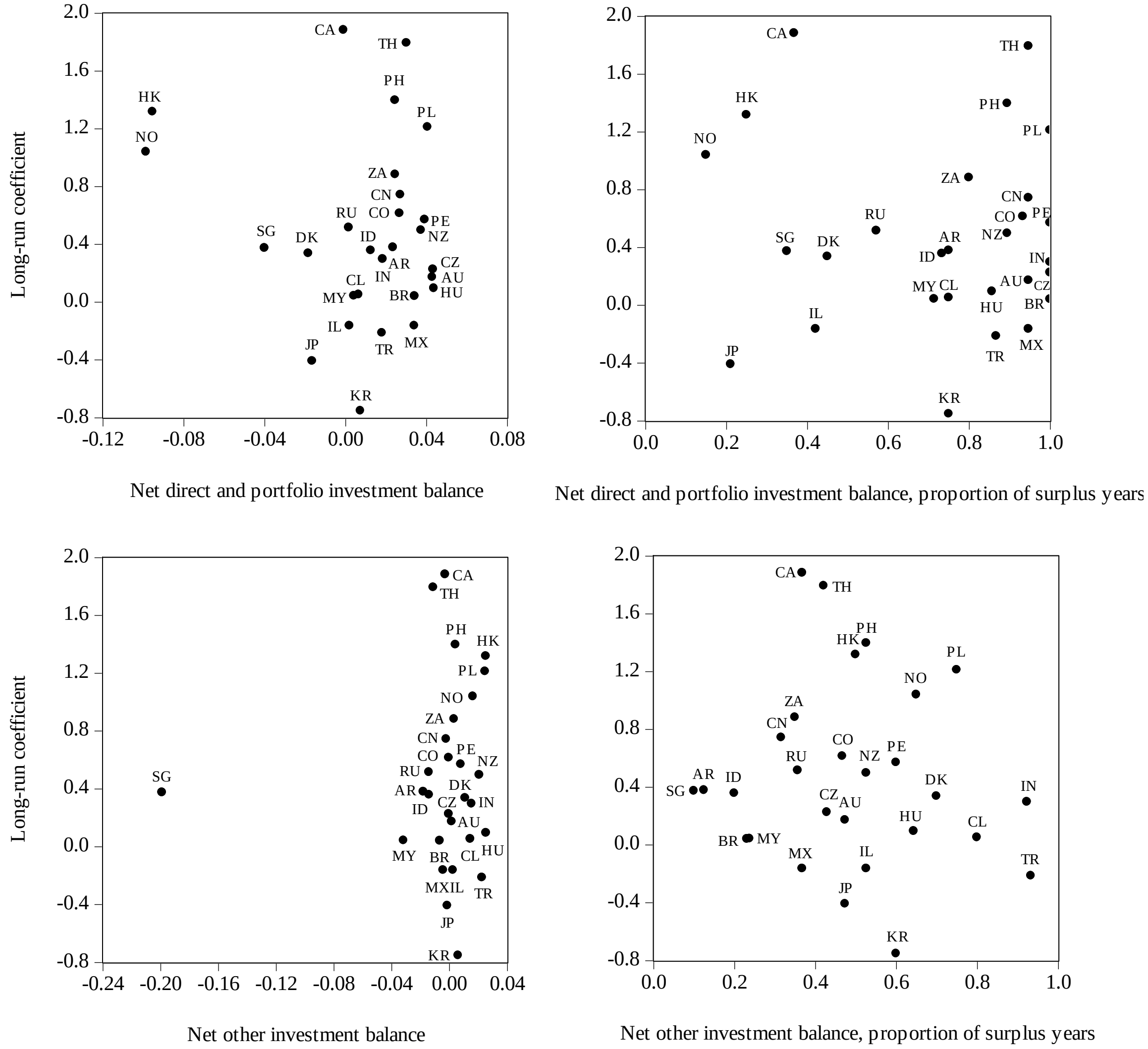
Graph 6.4: Long-run Real Intervention Effects on Real Broad Money Change and Country Characteristics



<u>Graph 6.4</u>: Continued



Graph 6.4: Continued



6.2.3 Regression Diagnostics

In this section, we provide a summary assessment of individual country baseline regressions drawing on the results of diagnostic tests. The diagnostic tests mainly consist of those for serial correlation, heteroscedasticity and normality in the regression residuals; and regression misspecification (Ramsey's RESET). The issue of parameter stability is addressed in section 6.2.4.

In Table 6.10, we indicate with a tick if the final parsimonious change in real broad money regression for each country has lagged dependent variables as regressors. Their presence may lead to inconsistent coefficient estimates if serial correlation is detected. We also indicate in the corresponding diagnostic tests columns if there was a rejection of the null hypothesis for specific tests and the associated level of statistical significance. If serial correlation, heteroscedasticity or non-normality was only detected in the unrestricted regression but not in the final parsimonious regression, we indicate as such.

Small amounts of serial correlation are widely present across our individual country regressions. For 11 out of the total 22 cases, serial correlation is detected only in the unrestricted regressions. In almost all other instances, there are inconsistencies between the results from the F-test and the LM test. Robust standard errors are used in the baseline regressions for China, Indonesia, Korea, Argentina, Brazil, Colombia, Egypt, Israel, Turkey, Japan and Norway.[97] There are only three countries where lagged dependent variables are regressors in the presence of relatively strong serial correlation in the final parsimonious regression – Korea, Israel and Japan.

[97] Robust standard errors to correct for heteroscedasticity are not used in the case of the Philippines because they worsen regression diagnostics, leading to serial correlation and heteroscedasticity in the parsimonious specification.

Table 6.10: Summary of Results for Diagnostic Tests of Individual Country Real Broad Money Growth Baseline Regressions

Country	AR variables	Diagnostic Tests	Country	AR variables	Diagnostic Tests
China	✓	Serial correlation**^ RESET failure*	Peru		Serial correlation **#^
Hong Kong		Serial correlation#^	Czech Republic	✓	Serial correlation*^
India	✓	Serial correlation#^	Egypt	✓	Serial correlation*^
Indonesia	✓	Serial correlation*^	Hungary		Serial correlation#^
Korea	✓	Serial correlation**	Israel	✓	Serial correlation**
Malaysia	✓	Serial correlation#^	Poland	✓	Serial correlation*^
Philippines	✓	Serial correlation#^ Heteroscedasticity**	Russia	✓	Serial correlation**^
Singapore	✓	Serial correlation#^	South Africa	✓	
Taiwan	✓		Turkey		Serial correlation #^
Thailand	✓		Australia	✓	
Argentina		Serial correlation # RESET failure*	Canada	✓	
Brazil	✓	Serial correlation*^	Denmark		
Chile			Japan	✓	Serial correlation*** Non-normality** RESET failure*
Colombia	✓	Serial correlation **#	New Zealand	✓	Serial correlation#^
Mexico	✓	Serial correlation #^	Norway		Heteroscedasticity*

✓ Indicates presence of lagged values of the dependent variable as regressors.
***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.
Serial correlation or heteroscedasticity detected in the unrestricted regression only. No evidence of serial correlation or heteroscedasticity in the final parsimonious regression.
^ Of the serial correlation tests, the Breusch-Godfrey LM statistic (NR^2) is significant but not the F-statistic for the joint significance of all lagged residuals.

Given complex dynamics and indications of both positive and negative serial correlation in the baseline regressions, we abstain from attempting to draw generalised conclusions on the direction of possible bias in the coefficients for real intervention. We do not, however, expect this bias to be particularly strong since the diagnostic tests point to relatively weak serial correlation. Furthermore, our baseline regressions and the subsequent analysis presented have been geared towards comparing relative effects across countries rather than focussing on the absolute values of coefficients for specific countries.

6.2.4 Robustness Analysis

In this section, we evaluate the robustness of the baseline coefficients we presented in Table 6.1. First, we assess if using robust standard errors for those countries that displayed mixed results in the tests for serial correlation would substantially change the outcomes on the intervention effects. Next, we compare the results from the baseline regressions against the results from unrestricted regressions. Thirdly, we also consider the stability of the coefficients from the baseline regressions over time.

6.2.4.1 Robust Standard Errors for Selected Individual Country Regressions

For some of our baseline regressions, we used robust standard errors, in particular, based on the Newey-West HAC covariance matrix method since serial correlation appeared to be more prevalent than heteroscedasticity. We used these only when there was consistency in the results of the F-test and LM test for serial correlation.

In this subsection, we apply robust standard errors to the baseline regressions that display serial correlation, either in the unrestricted form or in the final parsimonious specification, as indicated by the LM test, even if the F-test does not provide similar evidence. The robust standard errors are used from the beginning of the estimation in our general to specific modelling approach. This leads to some differences in the variables that are retained in the final parsimonious specifications when compared to the baseline scenarios. The results for the coefficients on real intervention effects for the countries in question are reported in Table 6.11. We note that there are three countries for which the results differ quite substantially from the baseline coefficients – Hong Kong, the Philippines and the Czech Republic. The results for diagnostic tests for all the countries are either similar or slightly worse. The effects of the changes to the coefficients are assessed by re-evaluating the equality tests and bivariate regressions that were carried out in subsection 6.2.2 using the coefficients from Table 6.11.

<u>Table 6.11</u>: Robustness Analysis of Real Intervention Effects on Real Broad Money Change – Use of Robust Standard Errors for Selected Countries

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Hong Kong	0.719*** [3.182]	2.092*** [23.914]
	1998q1-2010q2	
India	0.240* [1.827]	0.320 [1.671]
	1997q3-2010q2	
Malaysia	0.212*** [3.318]	0.102 [1.357]
	1991q2-2010q2	
Philippines	-0.188 [-0.919]	-0.471 [-0.779]
	1991q1-2010q2	
Singapore	0.173*** [3.414]	0.355** [6.131]
	1990q2-2010q2	
Mexico	-0.188** [-2.612]	-0.103 [1.088]
	1991q1-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ which is not removed in the general to specific modelling process.

<u>Table 6.11</u>: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$ (i) Contemporaneous α_{20}	(ii) Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Peru	0.192*** [3.137]	0.501*** [57.277]
	1995q2-2010q2	
Czech Republic	-0.273** [-2.185]	0.069 [0.655]
	1997q2-2010q2	
Hungary	0.037 [0.626]	0.125 [1.799]
	1996q2-2012q2	
Poland	-0.019 [-0.328]	1.042** [6.052]
	1998q1-2010q2	
Russia	0.268** [7.395]	0.649** [55.365]
	1996q2-2010q2	
New Zealand	0.211 [1.274]	0.410** [6.607]
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest t-statistic each time. This applies to all regressors except the contemporaneous effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ which is not removed in the general to specific modelling process.

In the following tables, Table 6.12 and Table 6.13, we highlight selected results from the subgroup equality tests[98] and bivariate regressions respectively for which there are changes to statistical significance arising from the use of the coefficients which were presented in Table 6.11. In our assessment, caution needs to be exercised in reading these results as it would appear that the exceptionally large short-run and long-run coefficients on real intervention effects for Hong Kong exert substantial influence on the changes we observe in regard to the bivariate regressions. Even so, the changes themselves are not major, in that there are only a

[98] The number of countries in each quartile beginning with the upper quartile is as follows: 7, 14, and 7 respectively, for both the short-run and long-run coefficients.

few differences to statistical significance. Otherwise, the signs on the regression coefficients and the ordering of means and medians (in particular, the largest or smallest value) of subgroups generally remain the same even if the absolute values have changed.

Table 6.12: Sensitivity Analysis of Equality Tests with the use of Robust Standard Errors for Selected Countries

(a) Differences in Short-run Intervention Effects between Groups of Countries					
	Current Account (CA) Balance	**Group Mean of Intervention Effect**			**Equality Test Statistic**
	CA surplus	0.209			3.659*
	CA deficit	0.124			
Baseline scenario reference: Tables 6.5					
(b) Differences in Long-run Intervention Effects between Groups of Countries					
	CA surplus	0.659			2.861*
	CA deficit	0.218			
Baseline scenario reference: Tables 6.5					
(c) Differences in Country Characteristics Grouped by Boxplot Quartiles of Short-run Intervention Effects					
	Country Characteristic	**Subgroup Average/[Median] of Characteristic**			**Equality Test Statistic**
		Upper quartile	**Inter-quartile**	**Lower quartile**	
1.	Current account average balance	[3.436]	[-0.482]	[-1.988]	3.363
2.	Intervention volatility	[0.538]	[0.743]	[0.416]	5.017*
Baseline scenario reference: Tables 6.6(a)					
(d) Differences in Country Characteristics Grouped by Boxplot Quartiles of Long-run Intervention Effects					
	Surplus quarters	[0.673]	[0.594]	[0.680]	4.903*
Baseline scenario reference: Tables 6.6(b)					

The results presented are only those for which there have been changes to the statistical significance of the equality test statistics in comparison to the baseline scenario.
Differences in mean/median: ***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 6.13: Sensitivity Analysis of Bivariate Regressions with the use of Robust Standard Errors for Selected Countries

Country Characteristic (Regressor in bivariate regression)		Dependent Variable: Short-run Real Intervention Effect	
		Coefficient	**t-statistic**
1.	Intervention volatility (FXIV)	0.179	2.546**
2.	Surplus periods (FXIS)	-0.578	-1.287
3.	Capital account openness (KAO)	0.395	2.395**
4.	Net direct and portfolio investment balance (DIPIB)	-2.644	-2.059**
5.	Net other investment balance surplus years (OIS)	-0.334	-1.496
Baseline scenario reference: Table 6.8			
		Dependent Variable: Long-run Real Intervention Effect	
1.	Intervention volatility (FXIV)	-0.172	-1.332
2.	Current account openness (CAO)	0.217	1.675*
3.	Capital account openness (KAO)	1.055	2.427**
4.	Net direct and portfolio investment balance (DIPIB)	-6.374	-1.852*
Baseline scenario reference: Table 6.9			

The results presented are only those for which there have been changes to the statistical significance of the regressors in comparison to the baseline scenario.
***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

6.2.4.2 *Real Intervention Effects from Unrestricted Regressions*

In Tables 6.14 and 6.15 we present the results for the short-run and long-run coefficients on real intervention effects derived from unrestricted regressions (all the lags of all the explanatory variables as per equation (6.1) have been kept intact, regardless of statistical significance). We still include the impulse dummy variables that appear in the baseline restricted regressions. When compared to the baseline results, the coefficients for both the short-run and long-run effects tend to exhibit lower statistical significance in most instances. This is not unexpected given the increase in the number of explanatory variables and likely multicollinearity across these variables. The differences in terms of economic significance vary across country groups as can be seen from the group averages, with the least difference observed for the Asian countries. Nevertheless, sample correlations between the unrestricted regression results and the baseline restricted regression results are quite high at 0.91 and 0.81 for the short-run and long-run coefficients respectively.

Using the coefficients on short-run and long-run real intervention effects from the unrestricted regressions, in Table 6.16, we highlight the results for equality tests based on the country groups from Table 6.5 and the new boxplot quartiles[99] (baseline scenario: Tables 6.6(a) and (b)) for which there are changes to statistical significance. We do the same for the bivariate regressions in Table 6.17 (baseline scenario: Tables 6.8 and 6.9). We observe that for the equality tests, the changes are mostly to statistical insignificance of the relevance of several country characteristics for the short-run intervention effects. Meanwhile for the bivariate regressions, we note that several regressors are now statistically significant in the regressions with long-run intervention effects as the dependent variable. The results for the bivariate regressions, however, appear to be influenced by the large coefficients for Hong Kong and Australia. Nevertheless, it is worth highlighting that the relative sizes or ordering (monotonic or otherwise) of the characteristics in question and the signs on

[99] The number of countries in each quartile beginning with the upper quartile is as follows: 7, 14, and 7 for the short-run coefficients; and 6, 15, and 7 for the long-run coefficients.

coefficients in the bivariate regressions are generally unchanged.[100] Thus, in our assessment, these results do not contradict the baseline scenario.

Table 6.14: Robustness Analysis of Real Intervention Effects on Real Broad Money Change - Individual Country Results from Unrestricted Regressions

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$ (i) Contemporaneous α_{20}	(ii) Long-run multiplier $\alpha_{2,LR}=\sum_{i=0}^{4}\alpha_{2i}\Big/(1-\sum_{i=1}^{4}\alpha_{1i})$
Asia		
China	0.021 [0.120]	0.692* [3.274]
	1991q2-2010q2	
Hong Kong	0.510 (1.167)	2.485** (6.687)
	1998q1-2010q2	
India	0.198 (0.819)	0.163 (0.162)
	1997q3-2010q2	
Indonesia	0.445** [2.157]	0.388 [1.923]
	1995q2-2010q2	
Korea	0.058 [0.270]	-0.890 [1.389]
	1991q2-2010q2	
Malaysia	0.212*** (2.939)	-0.390 (2.026)
	1991q2-2010q2	
Philippines	0.039 (0.169)	0.443 (0.296)
	1991q2-2010q2	
Singapore	0.144 (1.612)	0.637 (1.160)
	1991q2-2010q2	
Thailand	0.167 (1.236)	1.181 (1.730)
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4}\alpha_{2i}/(1-\sum_{i=1}^{4}\alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

[100] The exceptions are the sign for surplus periods, which turns positive, and for net other investment balance, which turns negative, in the respective bivariate regressions with long-run intervention effects as the dependent variable. Nevertheless, both regressors remain statistically insignificant.

Table 6.14: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$ (i) Contemporaneous α_{20}	(ii) Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Latin America		
Argentina	0.391** [2.267]	0.432 [0.917]
	1995q2-2010q2	
Brazil	0.236** [2.136]	-0.022 [0.004]
	1997q4-2010q2	
Chile	-0.040 (-0.258)	-0.225 (0.373)
	1991q2-2010q2	
Colombia	0.197 [0.725]	0.178 [0.135]
	1995q2-2010q2	
Mexico	-0.195 (-1.459)	-0.118 (0.168)
	1991q2-2010q2	
Peru	0.140* (1.750)	0.378* (3.330)
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t and F statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

Table 6.14: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Other Emerging Market Economies(EMEs)-Europe, Middle East and Africa		
Czech Republic	0.015 (0.052)	0.360 (1.246)
	1997q2-2010q2	
Hungary	0.019 (0.155)	0.144 (0.408)
	1996q2-2010q2	
Israel	0.054 [0.376]	-0.326* [3.190]
	1991q2-2010q2	
Poland	-0.096 (-0.646)	0.965 (0.254)
	1998q1-2010q2	
Russia	0.291*** (3.725)	0.691** (5.337)
	1996q3-2010q2	
South Africa	-0.238 (-0.718)	1.170** (4.063)
	1991q2-2010q2	
Turkey	-0.292 [-1.649]	-0.303 [0.197]
	1995q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%;
  *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.

Table 6.14: Continued

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Developed Economies		
Australia	0.251 (0.277)	-1.760 (0.094)
	1991q2-2010q2	
Canada	0.238 (0.526)	2.197 (0.552)
	1991q2-2010q2	
Denmark^	-0.146 (-0.803)	-0.114 (0.076)
	1991q1-2010q2	
Japan	-0.567 [-1.216]	-0.940 [1.838]
	1991q2-2010q2	
New Zealand	0.283 (1.325)	0.531 (1.966)
	1991q2-2010q2	
Norway	0.346*** (3.663)	0.908*** (19.102)
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.
- ^Excludes impulse dummy variables which appear in the baseline restricted regression. Regressors may be perfectly collinear with the inclusion of the impulse dummy variables.

<u>Table 6.15</u>: Robustness Analysis of Real Intervention Effects on Real Broad Money Change - Group Averages based on Unrestricted Regressions

Group	The group average effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Asia	0.199 (1.165)	0.523 (2.072)
Latin America	0.122 (0.860)	0.104 (0.821)
Other EMEs	-0.035 (1.046)	0.386 (2.099)
Developed Economies	0.068 (1.302)	0.132* (3.938)
TOTAL	**0.096** **(1.222)**	**0.315** **(2.211)**
Sample standard deviation	*0.239*	*0.871*
Correlation with baseline restricted regression results:	*Correlation (t-statistic)*	
Full sample	*0.91**** *(11.506)*	*0.81**** *(7.031)*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average t statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic.
  The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the t-and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
- The results are based on unrestricted regressions, which include all regressors regardless of statistical significance.
- Data excludes Egypt and Taiwan.

Table 6.16: Sensitivity Analysis of Equality Tests with the use of Results from Unrestricted Regressions

Differences in Country Characteristics Grouped by Boxplot Quartiles of Short-run Intervention Effects					
Country Characteristic		**Subgroup Average/[Median] of Characteristic**			**Equality Test Statistic**
		Upper quartile	**Inter-quartile**	**Lower quartile**	
1.	Current account average balance	[3.436]	[-0.010]	[-1.988]	1.682
2.	Capital account surplus years	0.500	0.743	0.689	1.658
3.	Capital account average balance	[-0.313]	[2.282]	[2.647]	1.454
4.	Net direct and portfolio investment balance surplus years	0.614	0.799	0.718	1.099
5.	Net direct and portfolio investment average balance	[1.261]	[2.568]	[1.814]	1.107
6.	Reserve accumulation	[0.144]	[0.386]	[0.203]	4.874*
Baseline scenario reference: Tables 6.6(a)					

The results presented are only those for which there have been changes to the statistical significance of the equality test statistics in comparison to the baseline scenario.
Differences in mean/median: ***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 6.17: Sensitivity Analysis of Bivariate Regressions with the use of Results from Unrestricted Regressions

Country Characteristic (Regressor in bivariate regression)		**Dependent Variable: Short-run Real Intervention Effect**	
		Coefficient	**t-statistic**
1.	Intervention volatility (FXIV)	0.160	2.432**
2.	Surplus periods (FXIS)	-0.536	-1.286
3.	Capital account openness (KAO)	0.275	1.719*
Baseline scenario reference: Table 6.8			
		Dependent Variable: Long-run Real Intervention Effect	
1.	Intervention volatility (FXIV)	0.517	2.106**
2.	Exchange rate flexibility (ERF)	-0.112	-1.900*
3.	Current account openness (CAO)	0.352	2.211**
4.	Capital account openness (KAO)	1.378	2.497**
5.	Net direct and portfolio investment balance (DIPIB)	-8.478	-1.941*
Baseline scenario reference: Table 6.9			

The results presented are only those for which there have been changes to the statistical significance of the regressors in comparison to the baseline scenario.
***significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

6.2.4.3 Stability Analysis of Baseline Real Intervention Effects

Using each country's final parsimonious specification, we run regressions from the beginning of the sample period available for each country, up to 2000q4 and 2005q4 respectively. In Table 6.18, we compare the short-run and long-run coefficients for real intervention effects from these regressions against those of the baseline regressions.

The averages for the coefficients across the full set of countries appear to be fairly stable over time. On an individual-country basis, however, there is some degree of instability, which is not unexpected since changes in economic and institutional factors over time are likely to influence the dynamics of real intervention effects on changes in real broad money. The coefficients appear to be particularly stable for Malaysia, Singapore, the Philippines, Thailand, Peru, Russia and Norway. For countries with coefficients that are statistically insignificant and/or closer to zero in value, there seem to be changes in the signs of the coefficients over time.

To make inferences about the statistical significance of the variations in intervention effects over time that we observe in Table 6.19, we formally test for changes in the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real broad money. On the basis of a single unknown breakpoint, in Table 6.19, we report the Quandt-Andrews supremum or maximum Wald statistic (sup-W), which allows for the identification of the most likely location for a breakpoint, as well as the Andrews-Ploberger average of the sequence of exponential Wald statistics (exp-W) which correspond to the tested breakpoints. Additionally, we present results of the traditional Chow test for known breakpoint, using the mid-point of the regression sample period for each country as the breakpoint to be tested.[101]

The results suggest that the coefficients under investigation have been stable over time for most countries. The countries exhibiting evidence of instability based on the Quandt-Andrews/Andrews-Ploberger tests are Argentina, Israel, New Zealand, and to a lesser degree, the Philippines and Indonesia. There is also relatively weak statistical significance of instability observed either in the Quandt-

[101] These are the same tests that were utilised and discussed in Chapter 5.

Andrews/Andrews-Ploberger test results or in the Chow test statistic for Colombia, Malaysia and Singapore. The breakpoints for Argentina and Israel seem to coincide with changes in each country's monetary policy framework - Argentina's currency board collapsed in 2002q1; and in Israel, the short-term interest rates were adopted as the policy instrument in 1995 following the gradual implementation of inflation-targeting in the prior few years. The breakpoint for the Philippines appears to precede the looser observance of intermediate money targets over 1995-1996; for Indonesia, the breakpoint occurs during the Asian financial crisis; while for New Zealand, the breakpoint occurs in advance of the changes to foreign exchange intervention policy in 2004 and changes to the liquidity management framework in 2006.

In *Appendix 7*, we present the results of Chow tests for selected countries, carried out for the specific dates where known changes to monetary policy frameworks have taken place. Most of the dates corresponding to changes to monetary policy frameworks do not appear to entail statistically significant changes to real intervention effects. However, the Chow test does indicate instability not picked up by the Quandt-Andrews test for Malaysia, Korea and to a lesser extent, Mexico. Statistical significance of instability is consistent with the Quandt-Andrews test with regard to the Philippines, Israel and New Zealand though the breakpoint dates differ in particular for New Zealand.

Taken together and in comparison to the results in Chapter 5, we can make several observations. Similar to the results for the real intervention effects on changes in real base money, the results here suggest that for many countries, the move to an inflation-targeting framework during the sample period did not signal a break in the real intervention effects on changes in real broad money. For Korea, the Philippines and Israel, there is tentative evidence that the breakpoints coincide with changes to monetary policy operating and intermediate targets, that is, from base money and monetary aggregates, to interest rates. With regard to Korea, Malaysia and Indonesia, the statistically significant breakpoints occur during the Asian financial crisis or just after, possibly as an indication of the structural change in these countries' respective balance of payments. It is also the case that while break dates appear statistically significant for real intervention effects on changes in broad money, they do not for real intervention effects on changes in base money (and vice-versa), with exceptions being Malaysia and New Zealand (See Table 6.14 and *Appendix 7* versus Table 5.15 and *Appendix 5*). With regard to New Zealand, while the statistically significant break date 2006q3 is common in both the base money and broad money regressions, it is interesting to note that real intervention effect changes in different directions – larger with regard to changes in real base money but smaller with regard to changes in real broad money (see the results of recursive regressions in Table 6.17 versus Table 5.14).

As an indication of the overall stability of the regression specifications we have used in our baseline analysis, we present the results of tests for stability across all parameters, in *Appendix 8*. The results indicate a greater amount of instability compared to the tests that focus on the subset of real intervention effects. This implies that there is instability in the relationship between changes in real broad money and the traditional money demand determinants.[102] The countries recording statistically significant breaks are Hong Kong, India, Malaysia, the Philippines, Argentina, Colombia, Mexico, the Czech Republic, Israel, Poland, Turkey, Japan and Norway. The test does not pick up instability in the case of Indonesia, possibly due to the large trimmings, and also, rather more oddly, in the case of New Zealand.

As a concluding comment for this subsection, we note that our results have to be viewed in the context of the sample sizes and results of diagnostic tests for our baseline regressions. In particular, though largely of minor degree, the presence of serial correlation or heteroscedasticity for some of our baseline regressions, and small sizes elsewhere despite a lack of diagnostic issues, affects the finite and asymptotic distributions of the test statistics under the null hypothesis.

[102] We also carried out the Bai-Perron test for multiple breaks across the full set of parameters. There are some differences when compared against the results of the Quandt-Andrews test as follows: (i) the Bai-Perron test identifies two breaks for Argentina; (ii) in contrast to the absence of statistically significant single breakpoints under the Quandt-Andrews test for Peru and Canada, the Bai-Perron test identifies three breaks respectively for each country; and (iii) for Colombia, Mexico, Hong Kong, Malaysia, New Zealand, Norway, Poland and Israel, the Bai-Perron test does not identify any breaks, in contrast to indications of some statistical significance based on the Quandt-Andrews test. The Bai-Perron test is subject to distortions in power and size (see Antoshin *et al*. (2008)), but nevertheless provides a check for the robustness of our stability analysis.

Table 6.18: Results from Recursive Regressions for Real Intervention Effects on Real Broad Money Change

Country	The effect of $\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{br,t-1}$ on $\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$					
	Short-run Coefficient (for sample ending)			Long-run Coefficient (for sample ending)		
	2000q4	2005q4	2010q2	2000q4	2005q4	2010q2
Asia						
China	0.213	0.100	-0.103	1.103*	0.789	0.743***
Hong Kong	n.a.	0.533	0.330	n.a.	1.825**	1.316**
India	n.a.	0.238	0.288*	n.a.	-0.015	0.297
Indonesia	n.a.	0.055	0.440**	n.a.	0.510*	0.357**
Korea	0.223	-0.030	0.048	-1.602**	-1.246	-0.752**
Malaysia	0.202**	0.218***	0.201***	0.073	0.114	0.042
Philippines	0.122	0.141	0.042	1.915	2.201**	1.396**
Singapore	0.198**	0.172***	0.169***	0.402*	0.319**	0.374**
Thailand	0.334	0.240	0.191*	2.088*	1.869**	1.792***
Latin America						
Argentina	0.488**	0.793***	0.512***	0.307	0.636***	0.379**
Brazil	n.a.	0.104	0.199***	n.a.	-0.364	0.041
Chile	0.076	0.134	0.052	0.076	0.134	0.052
Colombia	0.052	0.158	0.346***	0.158	0.309	0.614**
Mexico	-0.316***	-0.150*	-0.225**	-0.082	0.033	-0.164
Peru	0.245	0.268***	0.226***	0.595**	0.587***	0.569***

Regressions are estimated recursively using each country's full sample baseline estimating equation. Coefficient estimates are reported based on the regressions run from the beginning of the sample to 2000q4, 2005q4 and 2010q2 respectively, depending on the available sample size. The 2010q2 results correspond to those in Table 6.1 and are reported here for comparison purposes.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.
n.a. Not available or not reported, on account of short sample period.

Table 6.18: Continued

Country	The effect of ΔReal $FXR_{cb,t}$/Real $BM_{br,t-1}$ on ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$					
	Short-run Coefficient (for sample ending)			Long-run Coefficient (for sample ending)		
	2000q4	**2005q4**	**2010q2**	**2000q4**	**2005q4**	**2010q2**
Other Emerging Market Economies						
Czech Republic	n.a.	0.056	0.052	n.a.	0.312	0.226
Hungary	-0.086	-0.047	0.015	-0.072	0.125	0.095
Israel	-0.010	0.097	0.091	-0.233	-0.095	-0.164
Poland	n.a.	-0.130	0.007	n.a.	0.918	1.211*
Russia	0.301*	0.292***	0.292***	0.682**	0.522***	0.515***
South Africa	-0.406	-0.252	-0.020	0.848	0.694*	0.882**
Turkey	0.074	-0.310**	-0.300***	0.954	-0.168	-0.214
Developed Economies						
Australia	0.561	-0.087	0.081	1.078	-0.487	0.172
Canada	-0.396	0.230	0.371	-0.053	0.786	1.883*
Denmark	0.024	0.020	0.048	0.341	0.393**	0.336**
Japan	0.836	-0.411	-0.455	0.761	-0.364	-0.409
New Zealand	0.629**	0.340*	0.233	0.619**	0.343**	0.496***
Norway	0.373***	0.316***	0.296***	1.383***	1.107***	1.039***
*Average for all countries^*	*0.170*	*0.110*	*0.122*	*0.516*	*0.421*	*0.469*

Regressions are estimated recursively using each country's full sample baseline estimating equation. Coefficient estimates are reported based on the regressions run from the beginning of the sample to 2000q4, 2005q4 and 2010q2 respectively, depending on the available sample size. The 2010q2 results correspond to those in Table 6.1 and are reported here for comparison purposes.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.
n.a. Not available or not reported, on account of short sample period.
^ Average excludes Hong Kong, India, Indonesia, Brazil, Czech Republic, and Poland for the sample period ending 2000.

<u>Table 6.19</u>: Structural Break Tests for Real Intervention Effects on Real Broad Money Change

Country	Quandt-Andrews/ Andrews-Ploberger Tests[#]			Chow Test[#]	
	Unknown Breakpoint [Trimming]	Sup-W Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Asia					
China	2006q1 [15%]	17.501 (0.389)	6.108 (0.369)	2000q4	0.874 (0.555)
Hong Kong	2000q3 [15%]	7.121 (0.862)	2.286 (0.710)	2004q2	0.334 (0.888)
India	2005q3 [15%]	11.973 (0.644)	4.223 (0.493)	2004q1	1.014 (0.440)
Indonesia	1998q1 [15%]	20.320* (0.083)	7.784** (0.048)	2002q4	0.913 (0.510)
Korea	1999q2 [15%]	14.315 (0.284)	4.564 (0.280)	2000q2	1.107 (0.368)
Malaysia	1997q3 [15%]	14.407 (0.171)	5.220* (0.099)	2000q4	0.798 (0.556)
Philippines	1994q1 [15%]	20.166** (0.048)	7.453** (0.033)	2000q4	1.028 (0.416)
Singapore	2005q3 [15%]	12.530 (0.438)	4.473 (0.297)	2000q2	2.071* (0.068)
Thailand	1995q1 [15%]	8.423 (0.553)	2.184 (0.546)	2000q4	0.303 (0.875)
Latin America					
Argentina	2002q1 [15%]	21.763** (0.013)	8.273*** (0.007)	2002q4	3.330** (0.013)
Brazil	2001q3 [20%]	17.951 (0.410)	6.814 (0.333)	2004q2	1.550 (0.205)
Chile	2007q1 [15%]	9.010 (0.140)	1.489 (0.313)	2000q4	0.264 (0.769)
Colombia	2003q1 [15%]	14.912 (0.146)	5.235* (0.098)	2003q1	2.982** (0.021)
Mexico	1994q4 [15%]	16.316 (0.163)	5.696 (0.129)	2001q1	1.651 (0.152)
Peru	2007q3 [15%]	11.465 (0.547)	3.891 (0.422)	2003q1	0.547 (0.769)

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Table 6.19: Continued

Country	Quandt-Andrews/ Andrews-Ploberger Tests[#]			Chow Test[#]	
	Unknown Breakpoint [Trimming]	Sup-W Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Other Emerging Market Economies					
Czech Republic	2003q2 [40%]	3.983 (0.991)	1.617 (0.967)	2004q1	0.439 (0.889)
Hungary	2008q1 [15%]	11.811 (0.660)	3.898 (0.575)	2003q3	0.806 (0.588)
Israel	1994q4 [15%]	36.867*** (0.001)	14.674*** (0.001)	2001q1	0.834 (0.589)
Poland	2006q4 [25%]	16.414 (0.478)	6.261 (0.400)	2004q3	0.629 (0.773)
Russia	2000q1 [15%]	18.572 (0.140)	6.936* (0.091)	2003q2	0.724 (0.653)
South Africa	1994q3 [15%]	13.179 (0.377)	4.754 (0.247)	2000q3	1.242 (0.298)
Turkey	1997q3 [15%]	16.018 (0.103)	4.464 (0.178)	2003q1	0.390 (0.853)
Developed Economies					
Australia	2006q4 [15%]	20.934 (0.174)	7.276 (0.195)	2000q4	0.899 (0.533)
Canada	2006q3 [15%]	15.873 (0.650)	5.666 (0.580)	2001q1	0.358 (0.959)
Denmark	2002q2 [30%]	7.177 (0.520)	2.268 (0.442)	2000q3	0.310 (0.870)
Japan	2000q4 [30%]	10.447 (0.326)	4.143 (0.192)	2001q1	1.442 (0.222)
New Zealand	2003q2 [15%]	25.862*** (0.006)	9.743*** (0.005)	2001q1	2.081* (0.069)
Norway	1998q3 [40%]	15.017 (0.215)	5.558 (0.247)	2000q3	0.687 (0.701)

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

6.3 CONCLUSION

In this chapter, we set out to investigate the effects of real intervention on changes in real broad money over the period 1990q1-2010q2. Empirical work in this regard has been relatively scarce, with emphasis mainly on base money sterilisation.

Our first stage of empirical analysis was carried out using individual country multivariate dynamic regressions for a sample of 30 countries. This allowed us to consider the short-run and long-run effects of intervention on broad money changes separately and also to recognise heterogeneity across countries. We proposed that intervention influences changes in broad money differently than how it affects changes in base money. Such disconnect lends support for the focus on changes in broad money in understanding how intervention permeates the economy. Our findings support the disconnect hypothesis. Real intervention effects on changes in real broad money are on average higher than the effects on changes in real base money, both in the short run and long run. The average coefficients are 0.122 and 0.469 respectively compared with 0.075 and 0.111 respectively (excluding outliers, Egypt and Taiwan, in both instances). Crucially, however, for our sample of countries, equality tests and correlation analysis indicate that there is no relationship between the effects of intervention on changes in base money with its effects on changes in broad money.

Our results suggest that real intervention effects on changes in real broad money are generally higher in the long run compared to the short run, pointing to indirect effects that are relatively strong notwithstanding small contemporaneous effects. This is an interesting finding especially when set against previous studies which did not undertake dynamic analysis. The contemporaneous and indirect effects appear to be very much country-specific with various factors at play. The average coefficients may seem low, notwithstanding several individual countries with long-run coefficients greater than 1.000, as they are meant to capture the unique influence of intervention over and above the control variables, such as GDP which reflects income and wealth effects. Furthermore, not all balance of payments flows involve intervention – those that do may not translate into immediate effects, for example government or bank-related flows; and may not play a prominent role in subsequent credit creation. The central bank’s choice of sterilisation methods and use of foreign exchange swaps also affect the degree to which intervention has an impact on changes in broad money.

In our second stage of analysis, we used mean and median equality tests, and bivariate regressions to investigate the relevance of country characteristics for the real intervention effects on changes in real broad money. Similar to the results in the previous chapter, there are only a few instances of statistical significance of the differences in country characteristics in our baseline analysis.

With regard to the intervention indicators (intervention volatility, reserve accumulation and surplus periods), we do not find an unambiguous scenario of positive and statistically significant relationships with the short-run and long-run real intervention effects. Instead, baseline equality tests do not indicate statistically significant differences in the nature of intervention associated with the differences across the short-run and long-run intervention effects. Bivariate regressions of estimated real intervention effects against intervention volatility and reserve accumulation respectively also do not yield statistically significant results although the signs on the coefficients are positive. Robustness analysis, however, suggest a positive link between intervention volatility and intervention effects. Nevertheless, the results from the bivariate regressions have to be viewed with some caution as two countries, Hong Kong and Australia, appear to exert significant influence on the changes we observe when compared to the baseline scenario. Surplus periods have a rather surprising statistically significant negative relationship with short-run real intervention effects in the bivariate regression analysis, but we view this result with caution since it is heavily influenced by two data points. Furthermore, the robustness analysis does not reinforce this result.

In terms of monetary policy frameworks, there does not seem to be a difference in intervention effects between inflation-targeting and non-inflation-targeting countries. This is in contrast to the results for real intervention effects on changes in real base money, which suggested that non-inflation –targeting countries exhibited higher real intervention effects. Meanwhile, lower exchange rate flexibility is a statistically significant characteristic associated with higher short-run real intervention effects in the baseline bivariate regression analysis. Though not statistically significant, a similar negative relationship is observed with long-run intervention effects. The robustness analysis lends support to the negative relationship between exchange rate flexibility with both, short-run and long-run intervention effects.

Concerning the characteristics of the balance of payments flows, generally, while statistical significance is hard to come by, the monotonic orderings of the means/medians of subgroups in equality tests, and the signs on coefficients from the bivariate regressions provide interesting information about our sample of countries. Current account surpluses are associated with higher short-run real intervention effects – this is statistically significant in the baseline equality test, with a monotonic ordering of the characteristic that is consistent with the ordering of the subgroups for intervention effects; and is also captured as a positive (albeit statistically insignificant) relationship in the bivariate regression analysis. At the same time, the short-run real intervention effect appears to increase as the capital account balance declines monotonically – this is statistically significant in the median equality tests for the capital account balance and its subcomponent, net direct investment and portfolio balance. The statistical significances of the capital account balances are supported in the robustness analysis using robust standard errors for a wider number of countries. While no similar statistical significances are observed with the results on intervention effects from the unrestricted regressions, the monotonic orderings of the current and capital account balances are generally consistent with the baseline scenario. These results indicate that the net balances on the current and capital accounts matter for the short-run real intervention effects on changes in broad money. This is in contrast to the case of real intervention effects on changes in base money, where it was only capital account openness that mattered in the baseline scenario, and when capital account balances seemed to matter with robustness analysis, monotonic orderings of the characteristics were not observed.

The baseline bivariate regression analysis also reveals that the short-run real intervention effect on changes in real broad money has a statistically significant negative relationship with surplus years on net other investment balance. The results from the robustness analysis provide mixed support for the baseline scenario. Aside from the lack of correlation between the surplus years on the subaccount with intervention volatility, the tentative negative link may indicate that bank-related inflows do not immediately affect broad money and are therefore, associated with lower short-run intervention effects, or that bank-related outflows are indirectly related to current account surpluses, and therefore higher intervention effects.

In contrast, the long-run real intervention effects on changes in real broad money do not appear to be linked to any particular balance of payments characteristic in a statistically significant manner in the baseline scenario. Based on the relative closeness of the test statistics to statistical significance, it appears that the most likely important characteristics are current account and capital account openness, rather than net balances. There are also indications that the relationships between the capital account subcomponents with short-run and long-run intervention effects differ, in that short-run effects appear to be associated with deficits, but this is less clear in the case of long-run effects, particularly where other investment balances are concerned. Though not statistically significant, the monotonic ordering of the medians for other investment balances switches in the long run, and increases with higher intervention effects, whilst in the bivariate regression a positive, albeit statistically insignificant, relationship is observed. Tentatively, this may indicate the relevance of other investment balances, and in particular, bank-related flows for the long-run intervention effects on changes in broad money. In the robustness analysis section, although the use of the results from unrestricted regressions does not yield instances of statistical significance of the capital account balances in the equality tests, the orderings of the medians of these characteristics are generally consistent with the baseline scenario. Meanwhile, the results from the bivariate regressions of the robustness analysis point to the statistical significance of current account openness, capital account openness, and the net direct and investment portfolio balance for the long-run intervention effects. However, while consistent with the signs on the coefficients in the baseline scenario, we view these results with caution, given the influence of large coefficients for Hong Kong and Australia.

As final remarks in this chapter, it is useful to return to the open economy trilemma – the challenge of simultaneously pursuing monetary independence and exchange rate stability, amidst a high level of financial integration. Aizenman *et al.* (2010) suggest that a higher level of reserves allows for the pursuit of a higher weighted average of monetary independence and financial openness, given exchange rate stability. We have seen from our results that higher reserve accumulation *per se* is not associated with stronger real intervention effects on real broad money growth.

Nevertheless, there are indications that exchange rate stability and *de facto* capital account openness are positively linked to higher real intervention effects on real broad money growth. Using the measure of monetary independence provided by Aizenman *et al*. (2010), we investigate the link to real intervention effects on real broad money growth through equality tests. These results, along with tests for the other trilemma measures provided by Aizenman *et al.* (exchange rate stability and *de jure* financial openness), are presented in *Appendix 9: Equality Tests of the Aizenman-Chinn-Ito Trilemma Measures Grouped by the Boxplot Quartiles of Real Intervention Effects on Real Broad Money Change*. Although there are no statistically significant results, it is interesting to note that higher long-run real intervention effects are associated with lower average values of monetary independence, with the monotonic ordering and closeness to statistical significance generally much more apparent than for the short-run real intervention effects. This is observed across the baseline scenario and robustness analyses.[103]

In contrast, the association between real intervention effects on real base money growth and monetary independence is harder to discern (*Appendix 10: Equality Tests of the Aizenman-Chinn-Ito Trilemma Measures Grouped by the Boxplot Quartiles of Real Intervention Effects on Real Base Money Change*). There are no instances of statistical significance, and test statistics are relatively small across the board. Furthermore, the average values of monetary independence do not follow a monotonic ordering. Given our discussion in previous chapters, this is not surprising. High real intervention effects on real base money growth may indicate the use of reserve requirements, which in turn lends support to monetary independence. Overall, whilst tentative and requiring further investigation, it is a fair assessment that these results pertaining to monetary independence are in line with the thrust of our thesis – that it is broad money sterilisation that matters.

[103] For our sample of countries, we note that the Aizenman *et al.* (2010) *de jure* financial openness measure and our *de facto* capital account openness measure have a correlation of 0.463. The Aizenman *et al. de jure* financial openness and monetary independence measures have a statistically significant correlation of -0.489. However, the monetary independence measure has weaker (non-statistically significant) correlations with exchange rate stability (-0.274) and our *de facto* capital account openness measure (-0.165), both of which are more strongly correlated with intervention volatility and the long-run real intervention effects than the *de jure* financial openness measure.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

With the three main chapters of this thesis, we provided a new simple theoretical model for the analysis of the conduct of monetary policy with sterilised intervention, and carried out empirical analysis of the effects of foreign exchange intervention on base money and broad money growth respectively. Within these chapters we sought to answer the following key questions:

1. How do base money sterilisation and broad money sterilisation differ under an interest rate-targeting framework?
2. What are the implications of varying degrees of sterilisation for the policy interest rate?
3. Do countries exhibit differences in the effects of intervention on base money and broad money growth, and are there common country characteristics that can explain these differences?

In this concluding chapter we summarise our main findings and contribution (Section 7.2), discuss policy implications (Section 7.3), highlight the limitations of our study, and suggest areas for future research (Sections 7.4 and 7.5 respectively).

7.2 SUMMARY OF MAIN FINDINGS AND CONTRIBUTION

A primary motivation for our research undertaking is the lack of conceptual understanding underlying recent empirical literature on the degree of sterilisation; of how balance of payments flows and intervention affect base money and broad money, and permeate the economy. Most of these studies tend to focus on base money sterilisation and rather unrealistically assume that the change in the central bank's net domestic assets is the policy instrument. Consequently, the meaningfulness of base money sterilisation in the context of an interest rate-targeting framework is not investigated, nor the wider macroeconomic implications of varying degrees of base money and broad money sterilisation.

In Chapter 3, using a portfolio balance model consisting of three assets (money, bonds and equity) and simple balance sheet constraints, we showed that base money sterilisation does not imply broad money sterilisation. Depending on the instruments used, and, crucially, the sectors from which liquidity is absorbed (banks versus non-banks), the central bank's monetary operations will have significantly different effects on broad money growth, even as base money growth is completely sterilised. Incomplete broad money sterilisation, when intervention is a positive money supply shock, leads to looser monetary and financial conditions.

Then, based on simple structural equations of a stylised emerging market economy, we derived an optimal monetary policy reaction function which shows how the policy interest rate responds to various exogenous factors given varying degrees of broad money sterilisation. To justify the inclusion of broad money growth in the aggregate demand equation, we drew on the literature that advocates a role for money as a proxy for returns on other financial and real assets which are important for economic activity. The short-term policy interest rate is not a sufficient summary of these wider monetary and financial conditions.

Under the assumption of foreign exchange intervention as the only source of broad money growth, positive unsterilised money supply shocks result in lower bond and equity returns and higher excess liquidity in the banking system (Within an interest rate-targeting framework, money demand shocks are accommodated. Thus, with external inflows and intervention, asset returns either remain steady or decline, *ceteris paribus*). While these reflect cheaper financing conditions, from the perspective of savers, the money supply shocks also contain real balance effects. The implication for the policy interest rate is that it needs to respond more strongly to the exogenous factors affecting the output gap and inflation compared to the complete sterilisation scenario. However, an increase in the policy interest rate may trigger further capital inflows as the interest rate differential against the foreign interest rate widens. Thus, incomplete sterilisation reduces monetary policy independence and effectiveness.

Our model suggests that it is broad money sterilisation which matters in an interest rate-targeting framework rather than base money sterilisation. However, most countries do not actively sterilise the effects of intervention on broad money, particularly with respect to current account flows. Furthermore, unless sterilisation instruments (namely bonds) fulfil a specific demand, the effect of broad money sterilisation on monetary and financial variables can be unpredictable.

For the empirical analysis part of our thesis, the sample used consisted of 24 emerging market economies and six developed economies. Based on holdings of foreign exchange reserves scaled by GDP, the countries in our sample are fairly evenly distributed among the world rankings of countries. Simple correlation analyses of country characteristics indicate that for our sample of countries, current account openness and capital account openness are both strongly positively correlated with intervention volatility and reserve accumulation. However, it is the current account balance, rather than the capital account balance, that is *positively* correlated with openness, intervention volatility and reserve accumulation. Meanwhile, exchange rate flexibility is negatively correlated with openness, intervention volatility and reserve accumulation.

In Chapters 5 and 6, we carried out individual country regressions to estimate the effects of real intervention on real base money growth and real broad money growth respectively over the period 1990q1-2010q2. The regression analysis was carried out using the ARDL approach which allowed us to isolate contemporaneous and long-run effects of real intervention on the two money variables. Control variables were chosen based on behavioural money demand literature. We then compared the results for the real intervention effects against country characteristics through mean and median equality tests and bivariate regressions.

Our hypothesis with regard to real intervention effects on real base money growth was that there were unlikely to be economically significant effects unless a currency board was in operation, base money expansion was deliberate, or if reserve requirements were actively used in response to intervention. In contrast, the real intervention effects on real broad money growth were expected to be statistically and economically significant as well as showing greater dispersion depending on the types of balance of payments flows and the sectors involved; the nature of sterilisation methods; and the monetary policy stance. Thus, the effect of real intervention on real base money growth is disconnected from its effect on real broad money growth.

We found that on average, the real intervention effect on real broad money growth is higher than the effect on real base money growth. The baseline group average short-run and long-run coefficients are 0.122 and 0.496 respectively for real broad money growth and 0.075 and 0.111 respectively for real base money growth (excluding outliers, Egypt and Taiwan, in both instances). Equality tests and correlation analysis indicate there is no relationship between the real intervention effect on real broad money growth and its effect on real base money growth.

In testing for subgroup differences and the linear relevance of country characteristics in explaining the real intervention effects, we observed a general lack of statistical significance across the equality tests and bivariate regressions. This suggests that real intervention effects are very much country-specific and that heterogeneity cannot be ignored. Reserve accumulation does not appear to have a statistically significant link to the real intervention effects, neither on real base money growth nor on real broad money growth. In terms of monetary policy frameworks, based on equality tests, there is no evidence of a difference in real intervention effects on real broad money growth between inflation-targeting and non-inflation-targeting countries. This is in contrast to the results for real intervention effects on real base money growth, which suggest that non-inflation–targeting countries exhibit higher real intervention effects. This latter result, however, is influenced by the uniqueness of the monetary policy frameworks in Hong Kong and Japan – a currency board and prolonged base money expansion respectively. On the other hand, bivariate regressions indicate that lower exchange rate flexibility is a statistically significant characteristic associated with higher real intervention effects on real broad money growth. There is no similar statistically significant evidence of the relevance of exchange rate flexibility for the real intervention effects on real base money growth.

Concerning the characteristics of balance of payments flows, based on equality tests, we found that there are robust differences in capital account openness associated with the short-run and long-run real intervention effects on real base money growth. However these differences are non-monotonic – essentially we cannot infer a difference in capital account openness between the countries with the largest real intervention effects and those with the smallest real intervention effects. This may reflect differences in monetary policy frameworks and the choice of sterilisation instruments – open market operations versus required reserves. Nevertheless, the result is a tentative indication of the relevance of the gross size of capital flows rather than net balances. There is also tentative evidence from equality tests and bivariate regressions that real intervention effects on real base money growth are negatively associated with the number of surplus years on net direct and portfolio investment balances. This may reflect the lower volatility of the flows (negative correlation with capital account openness) and lower associated intervention (negative correlation with intervention volatility).

With regard to short-run real intervention effects on real broad money growth, as expected, equality tests suggest a positive (monotonic) association with current account balances and correspondingly a negative (monotonic) association with capital account balances. This is not surprising as the wealth effect associated with current account surpluses are much more likely to have a straightforward immediate link to broad money deposits, and as our simple model suggests, less likely to be sterilised. Furthermore, as we have noted, current account surpluses are positively related to intervention volatility for our sample of countries. In contrast, the long-run real intervention effects on real broad money growth do not appear to be robustly linked to any particular country characteristic in a statistically significant manner. Based on the relative closeness of the test statistics to statistical significance, it appears that the most likely important characteristics are current account and capital account openness rather than net balances. Furthermore, there are weak indications that the associations between capital account subcomponents with real intervention effects on real broad money growth tend to switch directions in the long run. For instance, though not statistically significant, higher long-run intervention effects are associated with monotonically rising medians for other investment balances, while in the bivariate regression, a positive, albeit statistically insignificant, relationship is observed. Tentatively, this may indicate the relevance of other investment balances, and in particular, bank-related flows for the long-run real intervention effects on real broad money growth.

Meanwhile, preliminary mean equality tests of average values of monetary independence do not point to statistically significant differences across the variations in real intervention effects on real broad money growth and real base money growth. Nevertheless, for the long-run real intervention effects on real broad money growth, the differences in monetary independence values are close to statistical significance and generally follow a monotonic ordering, with lower values associated with higher real intervention effects. These results can be viewed from two angles. On one hand, the negative association seems to support the premise that incomplete broad money sterilisation complicates monetary independence. On the other hand, the lack of statistical significance may suggest that the intervention effects are not high enough to warrant a problem; are perhaps not dominated by flows driven by interest rate differentials; and may not fully represent the money supply shocks that compromise monetary policy, as described in our simple model.

With our thesis, we have provided a new simple theoretical framework for understanding the differences between base money sterilisation and broad money sterilisation and their respective implications for a monetary policy framework where the policy instrument is a short-term interest rate. We show how policy dilemmas can arise under certain scenarios with incomplete broad money sterilisation. Economically and statistically significant real intervention effects on real broad money growth are a reflection of how balance of payments flows and intervention permeate the economy and affect monetary and financial conditions. In a departure from existing empirical literature which focuses on base money sterilisation, we have estimated the extent of real intervention effects on both, real base money growth and real broad money growth, and shown these to be different. With individual country multivariate dynamic regressions, we have been able to carefully take into account differences in monetary policy frameworks and capture both immediate and indirect real intervention effects. A similar attention to detail is missing from the current empirical literature which is culpable of inadequate and inaccurate conceptual foundations.

7.3 POLICY IMPLICATIONS

The findings of this thesis have several implications for academics undertaking related research and for policymakers. For academics, the primary implication is that a reorientation away from the exclusive focus on base money sterilisation is required. As we have highlighted, "full" base money sterilisation does not imply that liquidity associated with balance of payments flows does not pose a policy challenge, or vice-versa, that "incomplete" base money sterilisation reflects an inability to manage the impact of flows. Instead, academics need to devote more attention to the link between intervention and broad money growth. For example, even if required reserves are used, balance of payments flows and intervention can still have an immediate impact on broad money growth, unless sterilisation occurs at the private sector level. A sound understanding of the underlying mechanics, as we have provided, is required for any further research of sterilisation effectiveness and policy recommendations. Our findings cast doubts on the validity of conclusions from previous work, such as that the degree of broad money sterilisation is similar to that of base money sterilisation, that non-inflation-targeting countries tend to sterilise less than inflation-targeting countries, and that the sterilisation of FDI flows is less than the sterilisation of current account and non-FDI flows.

For policymakers, the simple model presented is a useful reference framework that illustrates how central banks in emerging markets are caught between a rock and a hard place, either with tight exchange rate management or relatively loosely managed exchange rates. On one hand, the adjustment mechanism of the exchange rate is muted, with possible build-up of imbalances; on the other, the economy may still be subject to the volatility associated with capital flows, and excessive movements in the exchange rate. Broad money growth driven by balance of payments flows and intervention can be symbolic of changing monetary and financial conditions elsewhere in the economy. In our model, broad money growth enters the output gap equation, the basis for which can be questioned. However, the channel through which broad money growth may affect the output gap is relatively more tangible, and this is through the prices on financial and real assets, and financing conditions.

Our model suggests that broad money sterilisation is a substitute for changes in the policy interest rate, in that higher broad money sterilisation reduces the need for increases in the policy interest rate. We are, however, cautious in assigning such a substitute role to broad money sterilisation in the achievement of inflation and output goals. Like the policy interest rate, broad money sterilisation can be viewed as a blunt instrument. The ambiguity over money demand and money supply shocks and mismatches in asset demand and supply leads to uncertainty about the effects of broad money sterilisation on the returns on assets and wider monetary conditions. There is the issue of the appropriate type of sterilisation instruments and the implications for other markets, namely the Government bond market. Furthermore, in the case where there is non-resident demand for the assets supplied, while excess liquidity and movements in asset prices and returns are reduced, this may in turn prolong inflows (not unlike a rise in the policy interest rate widening the differential against foreign interest rates). Additionally, the impact of the policy interest rate through the expectations channel as an established indicator of the monetary policy stance should perhaps not be underestimated.

We are thus, more inclined to view broad money sterilisation as a complementary policy. In fact, our model illustrates instances where there appears to still be a need to resort to additional policy instruments, such as prudential measures and restrictions on capital flows, particularly in addressing the risk of financial imbalances.

7.4 RESEARCH LIMITATIONS

We note that there are several limitations in our research, relating to the model we have developed; and with regard to the empirical analysis, in terms of sample, data and estimation techniques. Our simple model is a partial equilibrium framework without micro-foundations. Naturally, a micro-founded dynamic general equilibrium model will allow for more rigorous analysis, derived from first principles with well defined economy-wide behavioural relationships and constraints. A possible exploration within such a model is the welfare implications of different policy manoeuvres.

In our empirical analysis, an obvious aspect that can be improved upon and which may arguably affect the statistical significance of the equality tests and bivariate regressions is the number of countries in our sample. A notable gap in our sample is the lack of inclusion of major oil-exporting countries. Meanwhile, our measure of foreign exchange intervention is only an approximate, based on reserves data, and is thus subject to inaccuracies. The series can be adjusted to exclude approximations of interest income and used in the robustness analysis. Where available for a limited number of countries, the actual intervention data can also be compared against the proxy series.

Our ARDL approach to estimation, applied in a standard fashion for all countries, is not completely free of possible bias in coefficient estimates and misspecification. Not unexpectedly, the diagnostics are better for some individual country regressions than others. While we have highlighted the limitation of fixed and random-effects panel data models when there is slope heterogeneity, it may still be useful to compare our results against those from a panel data approach, particularly if we employed a random coefficients model. Panel data estimations would allow us to reduce the risk of endogeneity and use annual data with fewer lags, whilst being able to take into account differences across groups of countries. In particular, dummy variables can be used to capture the relationship between net domestic asset-driven money growth and different stages of financial development relative to a baseline category.

Another limitation of our empirical analysis is that we have done a comparison of averages – the coefficients on real intervention effects from regressions, regardless of statistical significance, against averages of country characteristics. A useful addition to the analysis is to incorporate interaction variables into our individual country regressions to capture the effects of "above/below average" time periods of intervention and balance of payments characteristics. A likely limitation in this regard is the lack of availability of balance of payments data on a quarterly frequency. The use of annual data within a panel data framework may be an alternative around this problem.

7.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Our simple theoretical model suggests that unsterilised positive money supply shocks emanating from balance of payments flows are linked to fluctuations in asset prices, and that with incomplete broad money sterilisation, there is reduced monetary policy effectiveness and independence – the foreign interest rate enters the monetary policy reaction function. Empirical analysis in this regard would consist of investigating the impact of intervention on asset prices, and exploring monetary independence and the trilemma configuration more carefully, conditional on the methods of sterilisation. Our empirical analysis has only dealt with estimating the real intervention effects on real base money growth and real broad money growth respectively, and investigating the possible factors for these results. A natural follow-on from this is the in-depth exploration of the implications of the results – the effects on wider monetary and financial conditions, and the link to different sterilisation instruments. Cross-country data on sterilisation instruments including the amounts of securities issued and the holders of these securities are generally not publicly available. This, however, does not preclude a detailed analysis of specific individual country experiences where data can be obtained.

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APPENDIX 1: SELECTED RECENT STUDIES ON STERILISATION IN DEVELOPING COUNTRIES[104]

	Source	Coverage	Methodology and Specification	Results
1.	Aizenman and Glick (2009)	Argentina (1992q1-2007q2), Brazil (1995q2 – 2007q2), China (1986q2-2007q2), India, Korea, Malaysia, Mexico, Thailand, Singapore (1985q1-2007q2).	Individual country OLS estimation: $\frac{\Delta DC_t}{RM_{t-4}} = \alpha + \beta \frac{\Delta NFA_t}{RM_{t-4}} + \delta \mathbb{Z} + u$ The net domestic credit (ΔDC) and net foreign assets (ΔNFA) variables are four quarter changes relative to the stock of base money (RM), lagged four quarters. $\Delta DC = \Delta RM - \Delta NFA$ ΔNFA = change in foreign exchange reserves in USD converted into national currency less change in foreign liabilities. $\mathbb{Z}$ are the following control variables: (i) $\Delta \ln(\text{Nominal GNP})$ (ii) $\Delta \ln(\text{Real GNP})\,;\Delta \ln(\text{inflation})$ A third type of regression consists of regressing ΔDC on different types of balance of payments flows along with $\Delta \ln(\text{Nominal GNP})$. Regressions include interaction dummy variables to capture breaks.	Selected sterilisation coefficients, for pre- and post- break periods (latter coefficient presented if break is statistically significant): Argentina = -0.783 and -1.065 Brazil = - 0.569 to -1.108 China = - 0.827 and -1.083 Korea = -0.744 and -0.937 India = -0.770 and -0.939 Malaysia = -0.874 Mexico = -0.934 and -1.037 Thailand = -0.929 Singapore = -0.993 (Note: Taken from Table 1, pages 785-787 of the paper.)
2.	Cardarelli *et al.* (2009)	52 countries: 8 advanced economies and 44 developing countries. 1991-2007.	Narrow sterilisation index[105] derived with values for each year estimated using 12 monthly observations for each country. Pooled OLS estimation as follows: $\Delta NDA_{it} = a_{it} + \beta_{it}\Delta NFA_{it} + u_{it}$ β_{it} is (-1) if there is full sterilisation. β_{it} is multiplied by (-1) to form index. NFA = foreign assets converted into USD less foreign liabilities converted into USD. NDA = Base Money – NFA. Base Money is also converted into USD.	Values for the index for each country grouping (Latin America, Central and Eastern Europe, East Asia, and other emerging markets) are generally between 0.4 and 1.0.There is relatively more variation for the East Asia grouping in the 1990s, with negative values in the index in 1994 and 1998-1999.

[104] Some of these studies do not specifically or solely focus on the nature of sterilisation but rather address the issues arising from and implications of capital inflows. In the analyses, however, brief estimations and discussions of sterilisation are presented. We focus on studies that have some overlap with our analysis in terms of the sample period.

[105] A broad sterilisation index was also computed based on the specification $\Delta M2_{it} = a_{it} + \delta_{it}\Delta NFA_{it} + u_{it}$. The results for this are not shown but the authors claim the results are consistent with the narrow sterilisation index. M2 is the sum of lines 34 and 35 in the IMF IFS.

APPENDIX 1: CONTINUED

	Source	Coverage	Methodology and Specification	Results
3.	IMF (2011) Box 1.4: Sterilization of Reserve Accumulation in Times of Large Capital Inflows	China, Hong Kong SAR, India, Malaysia, Singapore (1990q1-2011q1); Indonesia, Korea, Philippines, Thailand (2002q1-2011q1).	Panel data analysis with fixed country and period effects[106]: $\frac{\Delta NDA_t}{RM_{t-4}} = \alpha + \beta_1 \frac{\Delta NFA_t}{RM_{t-4}} + \beta_2 \frac{\Delta NFA_t}{RM_{t-4}} * FER + \beta_3 \frac{\Delta NFA_t}{RM_{t-4}} * K_{size} + \beta_3 \frac{\Delta NFA_t}{RM_{t-4}} * FER * K_{size} + \delta \mathbb{Z} + u$ where: ΔNDA and ΔNFA are four-quarter changes. ΔNDA includes required reserves. FER = fixed exchange rate indicator. K_{size} = capital inflow size indicator. $\mathbb{Z}$ = GDP_{t-1}, CPI_{t-1} and δ the associated coefficients.	The stronger and more persistent are capital inflows the lower is the degree of sterilisation in non-inflation targeting economies.
4.	Lavigne (2008)	35 countries emerging market economies in Asia, Latin America, Europe, and the middle east, along with oil producing countries. 1990-1996 and 2000-2006.	Narrow sterilisation ratio for each country: $\frac{\Delta NFA - \Delta CC}{\Delta NFA}$ Ratio = 1 indicates full sterilisation NFA = net foreign assets; CC = currency in circulation. Both are cumulative annual amounts. NFA adjusted for exchange rate revaluation effects by deflating central bank foreign asset levels by an index of the nominal exchange rate in USD (the base year is 2000 for all countries)	Country specific experiences vary. There however, appears to be greater sterilisation over 2000-2006 compared with 1990-1996. The ratio over 2000-2006 averaged 0.82 for the 11 countries that have had ΔNFA > USD20 billion since 2000 (0.74 over the period 1990-1996 (excluding Russia).

[106] The specification as described here is based on correspondence with the author of the box article, as details are not provided in the published document.

APPENDIX 1: CONTINUED

	Source	Coverage	Methodology and Specification	Results
5.	Ouyang *et al*. (2008)	India, Indonesia, Korea, Malaysia, Philippines, Taiwan, Thailand and Singapore. 1990q1-2005q3	2SLS panel data random effects estimation of the following simultaneous equations derived from a loss minimisation theoretical model: $\Delta NDA_t = a_0 + \alpha_1 \Delta NFA_t + x_1' \alpha_2 + u_{1t}$ $\Delta NFA_t = \beta_0 + \beta_1 \Delta NFA_t + x_2' \beta_2 + u_{2t}$ ΔNFA_t = Quarterly annual change in foreign reserves converted into national currency minus foreign liabilities in national currency. Excludes exchange rate revaluation effects. Scaled by GDP. $\Delta NDA_t =$ Quarterly annual change, inclusive of exchange rate revaluation effects, and scaled by GDP. Exchange rate revaluation effect = ΔNFA_{t-4} x $\left(\frac{s_t}{s_{t-4}} - 1\right)$ x_1= Annual change in log of M2 multiplier, quarterly annual change in log of CPI, cyclical income (deviation of log of real GDP from HP trend), quarterly annual change in log REER, quarterly annual change in government fiscal deficit scaled by GDP, quarterly annual change in exchange rate adjusted foreign interest rate (perfect foresight and static expectation), and interest rate volatility, and AR terms. x_2 = As above, except exchange rate volatility in place of interest rate volatility. x_1 and x_2 are either contemporaneous values or lagged one period.	Sterilisation coefficient estimated to be close to -1 in both sub-samples, suggesting full sterilization of reserve accumulation. 1990q1-1997q1 (perfect foresight: -1.046; static expectation: -0.966); 1998q3-2005q3 (perfect foresight: -1.265; static expectation: -0.846) Offset coefficient: 1990q1-1997q1 (perfect foresight: -0.796; static expectation: -0.838); 1998q3-2005q3 (perfect foresight: -0.601; static expectation: -0.514)
6.	Ouyang and Rajan (2011)	Singapore and Taiwan. 1990q1-2008q4	Single equation 2SLS and 3SLS estimation of simultaneous equations as in 5. Only the perfect foresight assumption is used for exchange rate expectation.	Singapore: Sterilisation coefficient (2SLS/3SLS) = -1.049/-1.090 Offset coefficient = -0.868/-0.922 Taiwan: Sterilisation coefficient = -1.052/-1.088 Offset coefficient = -0.861/-0.915

APPENDIX 1: CONTINUED

	Source	Coverage	Methodology and Specification	Results
7.	Ouyang *et al*. (2010)	China 2000m6- 2008m9	Methodology and specification similar to 6 above but applied to monthly data. Additionally, three different assumptions for exchange rate expectations are used – perfect foresight, forward exchange rate, and static expectation. Monthly GDP measured by distributing quarterly GDP data into the corresponding three months weighted by the industrial production index.	Sterilisation coefficient = -1.001 to -1.234 Offset coefficient = -0.517 to - 0.721
8.	Reinhart and Reinhart (2008)	30 developing countries. 2000-2006	Cross-section OLS estimation for each year as follows: $\Delta M_i = \alpha + \beta \Delta FA_i + u_i$ ΔM = percent change in narrow money, which consists of currency in circulation and transferable deposits in national currency. Note, this is a component of broad money and not a definition of base money. ΔFA = percent change in total reserves less gold in USD (IMF IFS line 1L.D). No discussion of regression diagnostics.	The elasticity of narrow money with respect to reserves has been close to zero (≤ 0.2) over 2000-2005 but rose to about 0.4 in 2006.
9.	Takagi (1999)	Indonesia, Korea, Malaysia, Philippines and Thailand.1987q1-1997q2	Individual country OLS estimation: $\Delta \ln\left(\frac{M_t}{P_t}\right) = d + h\Delta \ln\left(\frac{FA_{t-1}}{P_{t-1}}\right) + qv + u$ M =M1, M2; FA = Foreign assets in national currency (IMF IFS line 11), no adjustment for exchange rate revaluation effects. v comprises $\Delta \ln Y_i$, Δi and seasonal dummies.	Regardless of whether M1 or M2 is used, the coefficient h is not significantly different from zero. The only exception is in the case of the M2 regression for the Philippines (with Δi included), where h= - 0.108.

APPENDIX 2:

FACTORS AFFECTING REAL BROAD MONEY GROWTH AND REAL BASE MONEY GROWTH - DETAILED COUNTRY ESTIMATION RESULTS

This appendix contains three sections. The following are explanatory notes for each section.

Section A: Detailed Baseline Regression Results

We report for each country the detailed baseline regression results for real base money growth and real broad money growth respectively. The t-statistics corresponding to the coefficients are either default standard errors or robust standard errors as follows:

^: Newey-West HAC consistent covariances (Kernel options: Bartlett, Newey-West Automatic).
[#]: White heteroscedasticity consistent covariances.

For the diagnostic tests, the values shown are the associated p-values of test statistics. The test statistics are the Breusch-Godfrey LM chi-square statistic, and the F-statistic for joint significance of lagged residuals respectively, in the case of serial correlation diagnosis; the Breusch-Pagan chi-square statistic for heteroscedasticity; the chi-square statistic for the Jarque-Bera Normality test; and the t-statistic for RESET. For serial correlation diagnosis, the two tests are run with two, four and eight lags of residuals respectively. The results reported are generally the lowest p-values for both tests among the three sets.

For all coefficients and test statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.

Section B: Unit Root and Stationarity Tests for Variables in Levels and First Differences

ADF: Augmented Dickey Fuller, PP: Phillips-Perron, KPSS: Kwiatkowski, Phillips, Schmidt and Shin.

ADF and PP have the presence of a unit root (I(1)) as the null hypothesis (H_0). KPSS has trend or level stationarity (I(0)) as the null hypothesis.

The Zivot-Andrews (ZA) test has the presence of a unit root as the null hypothesis. The alternative hypothesis is trend or level stationarity with a single structural break. The ZA test is compared against the Clemente-Montanes-Reyes Additive Outlier (CMO-AO) test for two structural breaks (two mean shifts) for variables in levels where the presence of a trend is not clear, and for all variables in first differences. The shaded cells in the tables indicate instances where the ZA test result contrasts with the CMO-AO test result when the latter identifies two breaks at the 1% significance level.

Values shown are test statistics. For all test statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.

The content of the two parentheses indicate the inclusion of constant and/or trend (c = constant, t=trend) and the number of AR lags/bandwidth respectively. ADF lag length: sequential t-statistic significance (maximum lag=12). PP and KPSS bandwidth: Newey-West automatic, using Bartlett kernel. The inclusion of the deterministic regressors is based on statistical significance. Where statistically significant, these regressors are always included. Where these regressors are not statistically significant, they may still be kept based on graphical analysis of the likely alternative hypothesis, particularly for the tests with H_0= I(1). The lag selection for the ZA test is based on the Akaike Information Criterion.

For each variable, the span of data tested corresponds to the series length indicated in the individual country data notes (Section C). The maximum span is 1989q1-2010q2.

Section C: Country Data Notes

We provide details on the sources and definitions of data used in the individual country baseline regressions. The main source is the IMF IFS, with various editions downloaded via ESDS International, University of Manchester. http://www.esds.ac.uk/international/doipages/imfifs.asp. We provide the corresponding IFS code where relevant. Codes ending with ZF reflect pre-Standardised Report Forms (SRF) and codes ending with ZK reflect post-SRF. SRF was introduced in 2004 and is based on the methodology in the IMF Monetary and Financial Statistics Manual.

Section A: Detailed Baseline Regression Results

Argentina

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta \text{Real RM}_{\text{res,t}}/\text{Real RM}_{\text{res,t-1}}$			$\Delta \text{Real BM}_{\text{br,t}}/\text{Real BM}_{\text{br,t-1}}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
$\Delta \text{Real FXR}_{t}/\text{Real RM}_{t-1}$	0.116	2.170**	$\Delta \text{Real FXR}_{t}/\text{Real BM}_{t-1}$	0.512	2.857***
$\Delta \text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	-0.156	-2.574**	$\Delta \text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	-0.133	-2.573**
$\Delta \text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	0.145	2.160**	$\Delta\ln(\text{Real GDP})_{t}$	0.449	9.556***
$\Delta\ln(\text{Real GDP})_{t}$	-0.009	-5.318***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.398	3.141***
$\Delta\ln(\text{Real GDP})_{t-1}$	0.003	2.354***	$\Delta\ln(\text{Real GDP})_{t-2}$	-0.319	-3.145***
$\Delta\ln(\text{Real GDP})_{t-2}$	0.005	4.111*	$\Delta \text{Interest Rate}_{t}$	-0.006	-11.123***
$\Delta \text{Interest Rate}_{t}$	1.449	5.913***	$\Delta \text{Interest Rate}_{t-2}$	-0.002	-3.757***
$\Delta \text{Interest Rate}_{t-1}$	-0.741	-2.872**	$\Delta \text{Interest Rate}_{t-4}$	0.001	1.876*
$\Delta \text{Interest Rate}_{t-4}$	-0.445	-1.977***	$\Delta\ln(\text{REER})_{t-2}$	0.180	5.783***
$\Delta\ln(\text{REER})_{t}$	-0.755	-10.650***	$\Delta(\text{Inflation})_{t}$	0.692	2.941***
$\Delta\ln(\text{REER})_{t-1}$	0.319	2.813***	$\Delta(\text{Inflation})_{t-2}$	-0.607	-3.871***
$\Delta\ln(\text{REER})_{t-2}$	-0.496	-3.104***	$\Delta(\text{Inflation})_{t-3}$	0.401	2.707***
$\Delta(\text{Inflation})_{t-1}$	-0.641	-2.285**	$\Delta(\text{Inflation})_{t-4}$	-0.241	-2.215**
AR(1)	-0.242	-2.473**	S3 (seasonal dummy, q3)	-0.071	-3.702***
AR(2)	0.373	3.056***	S4 (seasonal dummy, q4)	0.033	2.484**
AR(3)	0.175	2.060**	Constant	0.025	4.365***
S2 (seasonal dummy, q2)	-0.372	-6.272***			
Constant	0.096	6.131***			
Long-run multiplier for $\Delta \text{Real FXR}_{t}/\text{Real RM}_{t-1}$ (F-statistic)	0.152 (0.889)		Long-run multiplier for $\Delta \text{Real FXR}_{t}/\text{Real BM}_{t-1}$ (F-statistic)	0.379 (6.513)***	
Diagnostics					
Adjusted R^2	0.87		Adjusted R^2	0.86	
Serial Correlation (2 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.807		LM Test (chi-square)	0.377	
F-Test	0.863		F-Test	0.493	
Heteroscedasticity	0.353		Heteroscedasticity	0.898	
Normality	0.809		Normality	0.745	
Ramsey RESET	0.210		Ramsey RESET	0.075*	
Sample Information					
Sample size (adjusted)	1994q4-2010q2		Sample size (adjusted)	1994q4-2010q2	
Observations	63		Observations	63	

Australia

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.011	-0.062	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.081	0.110
$\Delta\ln(\text{Real GDP})_t$	1.862	2.386**	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-1.252	-1.716*
$\Delta\ln(\text{Real GDP})_{t-1}$	-1.516	-2.218**	$\Delta\text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	1.253	1.776*
$\Delta\ln(\text{Real GDP})_{t-2}$	2.314	2.980***	$\Delta\ln(\text{Real GDP})_{t-2}$	0.409	1.663*
$\Delta\ln(\text{REER})_t$	-0.314	-2.060**	$\Delta\ln(\text{Real GDP})_{t-3}$	0.464	1.910*
$\Delta\ln(\text{REER})_{t-1}$	0.269	1.912*	$\Delta\text{Interest Rate(M)}_t$	-0.011	-2.343**
$\Delta\ln(\text{REER})_{t-4}$	0.250	2.145**	$\Delta\text{Interest Rate(M)}_{t-2}$	-0.009	-1.951*
$\Delta(\text{Inflation})_{t-1}$	-1.781	-3.096***	$\Delta\text{Interest Rate(M)}_{t-3}$	0.008	1.963*
$\Delta(\text{Inflation})_{t-2}$	-1.469	-2.576**	$\Delta\text{Interest Rate(B)}_{t-2}$	0.012	3.232***
$\Delta(\text{Inflation})_{t-4}$	1.477	2.608**	$\Delta\ln(\text{REER})_t$	0.118	2.381**
AR(1)	-0.342	-4.749***	$\Delta(\text{Inflation})_t$	-0.841	-3.539***
AR(2)	-0.136	-1.936*	$\Delta(\text{Inflation})_{t-3}$	0.864	4.680***
AR(3)	-0.190	-2.710***	$\Delta(\text{Inflation})_{t-4}$	-0.617	-2.797***
S3 (seasonal dummy, q3)	0.044	3.268***	AR(1)	0.302	2.831***
S4 (seasonal dummy, q4)	0.092	7.496***	AR(3)	0.220	2.063**
D1 (1997q4)	-0.216	-4.871***	S2 (seasonal dummy, q2)	0.019	4.286***
D2 (1999q3)	-0.198	-5.137***	S3 (seasonal dummy, q3)	0.017	3.810***
D3 (2008q4)	0.355	6.799***	S4 (seasonal dummy, q4)	0.026	6.462***
Constant	-0.037	-2.890***	Constant	-0.015	-3.042***
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.007 (0.004)		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.172 (0.004)	
Diagnostics					
Adjusted R^2	0.81		Adjusted R^2	0.51	
Serial Correlation (2 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.043**		LM Test (chi-square)	0.288	
F-Test	0.093*		F-Test	0.450	
Heteroscedasticity	0.243		Heteroscedasticity	0.477	
Normality	0.000***		Normality	0.112	
Ramsey RESET	0.620		Ramsey RESET	0.457	
Sample Information					
Sample size (adjusted)	1991q2-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	77		Observations	77	

Brazil

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.030	-0.331	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.199	2.792***
$\Delta\ln(\text{Real GDP})_t$	3.775	5.044***	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-0.128	-2.544**
$\Delta\ln(\text{Real GDP})_{t-3}$	-0.974	-2.232**	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	-0.272	-4.759***
$\Delta\ln(\text{Real GDP})_{t-4}$	-3.278	-4.512***	$\Delta\text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	0.233	3.137***
$\Delta\ln(\text{REER})_{t-2}$	0.338	2.283**	$\Delta\ln(\text{Real GDP})_{t-1}$	0.200	2.110**
$\Delta\ln(\text{REER})_{t-3}$	0.320	2.079**	$\Delta\ln(\text{Real GDP})_{t-2}$	0.281	5.661***
$\Delta\ln(\text{REER})_{t-4}$	0.381	2.246**	$\Delta\ln(\text{Real GDP})_{t-4}$	-0.246	-3.167***
$\Delta(\text{Inflation})_t$	2.345	1.757*	$\Delta\text{Interest Rate}_t$	-0.002	-4.924***
$\Delta(\text{Inflation})_{t-1}$	3.038	1.862*	$\Delta\text{Interest Rate}_{t-3}$	-0.001	-3.235***
$\Delta(\text{Inflation})_{t-2}$	-2.440	-2.035**	$\Delta\text{Interest Rate}_{t-4}$	0.002	5.272***
AR(4)	0.297	2.187**	$\Delta\ln(\text{REER})_{t-1}$	0.049	3.727***
Constant	0.028	1.917*	$\Delta\ln(\text{REER})_{t-2}$	-0.046	-4.508***
			$\Delta\ln(\text{REER})_{t-4}$	0.083	2.490**
			$\Delta(\text{Inflation})_t$	-0.973	-4.894***
			$\Delta(\text{Inflation})_{t-1}$	0.551	2.262**
			$\Delta(\text{Inflation})_{t-2}$	-0.156	-1.804*
			$\Delta(\text{Inflation})_{t-3}$	0.678	9.535***
			$\Delta(\text{Inflation})_{t-4}$	-0.860	-6.474***
			AR(1)	0.389	4.751***
			AR(2)	-0.168	-4.445***
			S2 (seasonal dummy, q2)	0.050	4.910***
			S3 (seasonal dummy, q3)	0.052	6.731***
			S4 (seasonal dummy, q4)	0.033	10.562***
			Constant	-0.019	-3.901***
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.030 (-0.331)		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.041 (0.025)	
Diagnostics					
Adjusted R^2	0.48		Adjusted R^2	0.71	
Serial Correlation (8 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.707		LM Test (chi-square)	0.062*	
F-Test	0.865		F-Test	0.483	
Heteroscedasticity	0.230		Heteroscedasticity	0.795	
Normality	0.498		Normality	0.391	
Ramsey RESET	0.023**		Ramsey RESET	0.188	
Sample Information					
Sample size (adjusted)	1997q2-2010q2		Sample size (adjusted)	1997q4-2010q2	
Observations	53		Observations	51	

Canada

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	0.027	0.781	ΔReal FXR_t/Real BM_{t-1}	0.371	1.245
ΔReal FXR_{t-1}/Real RM_{t-2}	0.093	2.823***	ΔReal FXR_{t-3}/Real BM_{t-4}	0.501	1.691*
$\Delta\ln(\text{Real GDP})_{t-4}$	-0.679	-2.029**	$\Delta\ln(\text{Real GDP})_{t-1}$	0.510	2.807***
$\Delta\ln(\text{REER})_{t-3}$	-0.243	-3.104***	$\Delta\text{Interest Rate}_{t-2}$	0.005	2.245**
$\Delta(\text{Inflation})_t$	-0.809	-2.739***	$\Delta\ln(\text{REER})_{t-1}$	0.085	2.161**
$\Delta(\text{Inflation})_{t-2}$	-0.712	-2.370**	$\Delta\ln(\text{REER})_{t-2}$	0.094	2.187**
AR(1)	-0.516	-6.544***	$\Delta\ln(\text{REER})_{t-3}$	0.077	1.838*
AR(2)	-0.384	-4.552***	$\Delta(\text{Inflation})_t$	-1.233	-6.465***
AR(3)	-0.306	-3.729***	$\Delta(\text{Inflation})_{t-1}$	-0.314	-1.902*
S2 (seasonal dummy, q2)	0.057	3.999***	$\Delta(\text{Inflation})_{t-4}$	-0.710	-3.956***
S3 (seasonal dummy, q3)	0.039	4.320***	AR(1)	-0.250	-2.197**
S4 (seasonal dummy, q4)	0.077	5.399***	AR(2)	0.203	2.023**
D1 (1999q4)	0.201	9.426***	AR(3)	0.342	3.530***
Constant	-0.025	-2.753***	AR(4)	0.242	2.124**
			S2 (seasonal dummy, q2)	0.009	1.675*
			S3 (seasonal dummy, q3)	0.014	2.969***
			S4 (seasonal dummy, q4)	0.027	4.948***
			Constant	-0.011	-2.728*
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	0.055 (4.811)**		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	1.883 (3.066)*	
Diagnostics					
Adjusted R^2	0.91		Adjusted R^2	0.70	
Serial Correlation (2 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.348		LM Test (chi-square)	0.222	
F-Test	0.426		F-Test	0.365	
Heteroscedasticity	0.369		Heteroscedasticity	0.381	
Normality	0.830		Normality	0.789	
Ramsey RESET	0.131		Ramsey RESET	0.530	
Sample Information					
Sample size (adjusted)	1990q4-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	79		Observations	77	

Chile

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{\text{res},t}/\text{Real RM}_{\text{res},t-1}$			$\Delta\text{Real BM}_{\text{br},t}/\text{Real BM}_{\text{br},t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.026	0.943	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.052	0.504
$\Delta\text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	0.055	2.027**	$\Delta\ln(\text{Real GDP})_{t-4}$	0.314	5.248***
$\Delta\ln(\text{Real GDP})_t$	0.921	3.593***	$\Delta\text{Interest Rate}_{t-1}$	-0.001	-2.303**
$\Delta\ln(\text{Real GDP})_{t-1}$	-1.262	-4.714***	$\Delta\text{Interest Rate}_{t-2}$	-0.001	-2.633***
$\Delta\ln(\text{Real GDP})_{t-2}$	-0.730	-3.385***	$\Delta\text{Interest Rate}_{t-3}$	-0.001	-2.689***
$\Delta\text{Interest Rate}_{t-2}$	-0.005	-3.118***	$\Delta\text{Interest Rate}_{t-4}$	-0.002	-4.360***
$\Delta(\text{Inflation})_{t-1}$	-1.147	-1.991*	$\Delta\ln(\text{REER})_{t-2}$	0.094	1.865*
$\Delta(\text{Inflation})_{t-2}$	1.188	1.865*	$\Delta(\text{Inflation})_t$	-0.410	-2.471**
AR(1)	-0.484	-10.203***	$\Delta(\text{Inflation})_{t-1}$	0.510	2.860***
D1(1992q1)	1.112	14.746***	Constant	0.017	8.429***
Constant	0.040	4.194***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.054 (3.936)*		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.052 (0.254)	
Diagnostics					
Adjusted R^2	0.87		Adjusted R^2	0.43	
Serial Correlation (2 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.121		LM Test (chi-square)	0.451	
F-Test	0.163		F-Test	0.504	
Heteroscedasticity	0.910		Heteroscedasticity	0.266	
Normality	0.780		Normality	0.236	
Ramsey RESET	0.833		Ramsey RESET	0.585	
Sample Information					
Sample size (adjusted)	1990q4-2010q2		Sample size (adjusted)	1990q3-2010q2	
Observations	79		Observations	80	

China

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic^
$\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$	0.158	2.638**	$\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$	-0.103	-0.647
$\Delta \text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	-0.316	-6.820***	$\Delta \text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	0.504	2.893***
$\Delta \text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	0.191	2.787***	$\Delta \ln(\text{Real GDP})_t$	0.381	6.432***
$\Delta \ln(\text{Real GDP})_t$	0.541	3.499***	$\Delta \ln(\text{Real GDP})_{t-1}$	0.264	6.497***
$\Delta \ln(\text{Real GDP})_{t-1}$	0.584	4.002***	$\Delta \ln(\text{Real GDP})_{t-2}$	0.149	2.872***
$\Delta \ln(\text{Real GDP})_{t-2}$	0.781	5.133***	$\Delta \text{Interest Rate}_t$	-0.010	-5.987***
$\Delta \ln(\text{Real GDP})_{t-3}$	0.648	3.686***	$\Delta \text{Interest Rate}_{t-2}$	-0.011	-5.041***
$\Delta \text{Interest Rate}_{t-2}$	-0.016	-2.819***	$\Delta \ln(\text{REER})_t$	-0.036	-2.123**
$\Delta \text{Interest Rate}_{t-3}$	0.013	1.882***	$\Delta \ln(\text{REER})_{t-3}$	-0.045	-2.231**
$\Delta \ln(\text{REER})_{t-1}$	0.186	2.725***	$\Delta \ln(\text{REER})_{t-4}$	-0.039	-1.834*
$\Delta \ln(\text{REER})_{t-3}$	0.156	3.548***	$\Delta(\text{Inflation})_t$	-0.797	-8.792***
$\Delta(\text{Inflation})_t$	-0.810	-4.868***	$\Delta(\text{Inflation})_{t-2}$	-0.248	-2.520**
$\Delta(\text{Inflation})_{t-1}$	0.295	2.396**	$\Delta(\text{Inflation})_{t-3}$	0.231	2.529**
$\Delta(\text{Inflation})_{t-3}$	0.571	4.325***	$\Delta(\text{Inflation})_{t-4}$	-0.209	-3.798***
$\Delta(\text{Inflation})_{t-4}$	-0.604	-2.499**	AR(1)	0.206	6.067***
AR(3)	0.238	2.579**	AR(2)	-0.094	-2.135**
S3 (seasonal dummy, q3)	0.103	2.609**	AR(3)	0.348	9.821***
S4 (seasonal dummy, q4)	0.161	3.028***	S2 (seasonal dummy, q2)	-0.101	-2.902***
Constant	-0.094	-4.312***	S3 (seasonal dummy, q3)	-0.071	-2.243**
			S4 (seasonal dummy, q4)	-0.205	-5.932***
			D1(1993q1)	0.204	17.829***
			Constant	0.094	4.295***
Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.043 (0.306)		Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.743 (9.289)***	
Diagnostics					
Adjusted R^2	0.77		Adjusted R^2	0.84	
Serial Correlation (4 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.068*		LM Test (chi-square)	0.049**	
F-Test	0.157		F-Test	0.143	
Heteroscedasticity	0.959		Heteroscedasticity	0.130	
Normality	0.684		Normality	0.148	
Ramsey RESET	0.953		Ramsey RESET	0.080*	
Sample Information					
Sample size (adjusted)	1991q2-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	77		Observations	77	

Colombia

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{\text{res},t}/\text{Real RM}_{\text{res},t-1}$			$\Delta\text{Real BM}_{\text{br},t}/\text{Real BM}_{\text{br},t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic^
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.144	1.982*	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.346	2.157**
$\Delta\text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	0.182	2.572**	$\Delta\ln(\text{Real GDP})_{t-3}$	0.486	2.687***
$\Delta\text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	0.347	4.715***	$\Delta\ln(\text{Real GDP})_{t-4}$	0.879	5.975***
$\Delta\text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	-0.123	-1.806*	$\Delta\text{Interest Rate}_t$	-0.003	-2.724***
$\Delta\ln(\text{Real GDP})_{t-1}$	2.455	4.933***	$\Delta\text{Interest Rate}_{t-2}$	-0.002	-1.842*
$\Delta\ln(\text{Real GDP})_{t-4}$	-1.471	-2.911***	$\Delta\ln(\text{REER})_t$	-0.117	-1.994*
$\Delta\ln(\text{REER})_t$	-0.224	-2.094**	AR(2)	0.436	5.427***
$\Delta\ln(\text{REER})_{t-1}$	-0.366	-2.744***	S3 (seasonal dummy, q3)	0.047	6.008***
AR(1)	-0.521	-13.439***	S4 (seasonal dummy, q4)	0.095	12.189***
S3 (seasonal dummy, q3)	0.028	1.748*	Constant	-0.042	-6.114***
S4 (seasonal dummy, q4)	0.232	12.041***			
Constant	-0.049	-3.824***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.362 (24.377)***		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.614 (4.577)**	
Diagnostics					
Adjusted R^2	0.89		Adjusted R^2	0.85	
Serial Correlation (2 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.040**		LM Test (chi-square)	0.306	
F-Test	0.073*		F-Test	0.413	
Heteroscedasticity	0.243		Heteroscedasticity	0.354	
Normality	0.633		Normality	0.698	
Ramsey RESET	0.217		Ramsey RESET	0.596	
Sample Information					
Sample size (adjusted)	1995q2-2010q2		Sample size (adjusted)	1995q2-2010q2	
Observations	61		Observations	61	

Czech Republic

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.069	1.760*	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.052	0.261
$\Delta\ln(\text{Real GDP})_{t-1}$	1.651	3.621***	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.178	1.895*
$\Delta\ln(\text{Real GDP})_{t-4}$	0.990	4.183***	$\Delta\ln(\text{Real GDP})_t$	-0.526	-2.026*
$\Delta\ln(\text{REER})_{t-1}$	-0.454	-2.099**	$\Delta\ln(\text{Real GDP})_{t-1}$	0.709	3.444***
$\Delta(\text{Inflation})_t$	-1.354	-2.413**	$\Delta\ln(\text{Real GDP})_{t-3}$	0.682	4.560***
$\Delta(\text{Inflation})_{t-4}$	-0.975	-1.868*	$\Delta\ln(\text{Real GDP})_{t-4}$	0.694	2.486**
AR(1)	-0.430	-4.175***	$\Delta\text{Interest Rate}_t$	-0.016	-2.788***
S3 (seasonal dummy, q3)	-0.109	-2.807***	$\Delta\text{Interest Rate}_{t-2}$	0.018	2.867***
D1(2004q3)	0.152	3.540***	$\Delta\ln(\text{REER})_t$	-0.228	-2.433**
D2(2008q4)	0.155	3.559***	$\Delta\ln(\text{REER})_{t-3}$	0.182	1.828*
Constant	0.008	0.894	$\Delta\ln(\text{REER})_{t-4}$	-0.220	-2.235**
			$\Delta(\text{Inflation})_t$	-0.572	-2.205**
			$\Delta(\text{Inflation})_{t-4}$	-0.792	-3.088***
			AR(1)	-0.316	-2.916***
			AR(2)	0.171	2.185*
			AR(3)	0.126	1.689*
			S2 (seasonal dummy, q2)	0.079	1.842*
			S4 (seasonal dummy, q4)	0.108	4.691***
			D1(2002q1)	-0.165	-10.524***
			D2(2002q2)	-0.076	-1.700*
			Constant	-0.042	-2.524**
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.048 (3.105)*		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.226 (1.529)	
Diagnostics					
Adjusted R^2	0.55		Adjusted R^2	0.86	
Serial Correlation (4 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.051*		LM Test (chi-square)	0.026**	
F-Test	0.105		F-Test	0.218	
Heteroscedasticity	0.622		Heteroscedasticity	0.446	
Normality	0.068*		Normality	0.522	
Ramsey RESET	0.242		Ramsey RESET	0.403	
Sample Information					
Sample size (adjusted)	1997q2-2010q2		Sample size (adjusted)	1997q2-2010q2	
Observations	53		Observations	53	

Denmark

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{\text{res},t}/\text{Real RM}_{\text{res},t-1}$			$\Delta\text{Real BM}_{\text{br},t}/\text{Real BM}_{\text{br},t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.015	-0.736	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.048	0.491
$\Delta\text{Interest Rate}_t$	-0.017	-2.582**	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	0.288	2.793***
$\Delta(\text{Inflation})_t$	3.709	2.141**	$\Delta\text{Interest Rate(M)}_{t-2}$	0.007	2.326**
$\Delta(\text{Inflation})_{t-2}$	5.786	3.090***	$\Delta\text{Interest Rate(B)}_{t-1}$	-0.017	-2.663***
$\Delta(\text{Inflation})_{t-3}$	4.723	2.598**	$\Delta\text{Interest Rate(B)}_{t-4}$	-0.003	-0.480
AR(1)	-0.623	-5.882***	$\Delta\ln(\text{REER})_t$	0.638	3.071***
AR(2)	-0.226	-2.175**	$\Delta\ln(\text{REER})_{t-1}$	-0.537	-2.510**
S4(seasonal dummy, q4)	0.036	2.482**	S4(seasonal dummy, q4)	-0.017	-2.866***
Constant	0.017	2.160**	D1(1991q1)	-0.163	-6.887***
			D2(2004q1)	0.079	3.354***
			D3(2004q2)	-0.094	-4.138***
			D4(2005q2)	0.077	3.426***
			Constant	0.014	4.465***
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.008 (0.536)		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.336 (5.334)**	
Diagnostics					
Adjusted R^2	0.44		Adjusted R^2	0.65	
Serial Correlation (8 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.506		LM Test (chi-square)	0.166	
F-Test	0.617		F-Test	0.247	
Heteroscedasticity	0.755		Heteroscedasticity	0.235	
Normality	0.294		Normality	0.697	
Ramsey RESET	0.721		Ramsey RESET	0.903	
Sample Information					
Sample size (adjusted)	1991q1-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	78		Observations	81	

Egypt

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	3.537	7.867***	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.524	4.481
$\Delta\text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	-1.423	-3.702***	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-0.395	-3.581
$\Delta\text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	-2.182	-6.143***	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.300	2.687
$\Delta\text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	1.178	3.253***	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	-0.428	-3.122
$\Delta\text{Interest Rate}_t$	-0.168	-5.659***	$\Delta\text{Interest Rate}_{t-2}$	-0.019	-2.349
$\Delta\text{Interest Rate}_{t-1}$	0.130	2.660**	$\Delta\ln(\text{NC/USD})_t$	0.110	7.630
$\Delta\text{Interest Rate}_{t-2}$	0.147	3.357***	$\Delta\ln(\text{NC/USD})_{t-3}$	-0.114	-5.549
$\Delta\text{Interest Rate}_{t-3}$	-0.150	-4.721***	$\Delta(\text{Inflation})_t$	-0.742	-9.116
$\Delta\ln(\text{NC/USD})_t$	0.636	2.318**	AR(1)	0.358	4.967
$\Delta\ln(\text{NC/USD})_{t-1}$	0.634	2.595**	AR(2)	-0.173	-3.091
$\Delta\ln(\text{NC/USD})_{t-3}$	-1.301	-5.402***	AR(3)	0.315	4.988
$\Delta(\text{Inflation})_{t-3}$	-2.804	-4.303***	AR(4)	0.371	4.972
AR(4)	0.426	2.758**	S2(seasonal dummy, q2)	0.012	2.313
S4(seasonal dummy, q4)	-0.038	-2.137**	S4(seasonal dummy, q4)	0.009	2.033
Constant	0.018	1.534	D1(2002q3)	-0.062	-15.458
			D2(2002q4)	0.074	12.252
			Constant	-0.006	-2.541
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	1.934 (6.221)**		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.013 (0.000)	
Diagnostics					
Adjusted R^2	0.84		Adjusted R^2	0.72	
Serial Correlation (8 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.005***		LM Test (chi-square)	0.064*	
F-Test	0.135		F-Test	0.113	
Heteroscedasticity	0.811		Heteroscedasticity	0.167	
Normality	0.438		Normality	0.864	
Ramsey RESET	0.353		Ramsey RESET	0.653	
Sample Information					
Sample size (adjusted)	2003q1-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	30		Observations	81	

Hong Kong

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	0.270	4.866***	ΔReal FXR_t/Real BM_{t-1}	0.331	1.145
ΔReal FXR_{t-1}/Real RM_{t-2}	-0.115	-2.220**	ΔReal FXR_{t-3}/Real BM_{t-4}	0.449	1.741*
$\Delta\ln(\text{Real GDP})_{t-1}$	-1.094	-3.073***	ΔReal FXR_{t-4}/Real BM_{t-5}	0.536	1.858*
$\Delta\ln(\text{Real GDP})_{t-4}$	-1.430	-3.499***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.450	4.186***
ΔInterest Rate_{t-2}	-0.040	-2.892***	$\Delta\ln(\text{Real GDP})_{t-2}$	0.285	2.380***
ΔInterest Rate_{t-4}	0.029	2.428**	$\Delta\ln(\text{Real GDP})_{t-3}$	0.658	4.267***
$\Delta\ln(\text{REER})_{t-1}$	-0.838	-2.106**	$\Delta\ln(\text{Real GDP})_{t-4}$	0.368	3.084***
$\Delta\ln(\text{REER})_{t-2}$	1.487	2.937***	ΔInterest Rate_t	-0.009	-3.062***
$\Delta\ln(\text{REER})_{t-3}$	-1.194	-2.640**	ΔInterest Rate_{t-1}	0.008	2.654**
$\Delta\ln(\text{REER})_{t-4}$	-0.788	-2.275**	$\Delta\ln(\text{REER})_t$	-0.232	-2.505**
$\Delta(\text{Inflation})_t$	5.214	5.041***	$\Delta\ln(\text{REER})_{t-4}$	-0.175	-1.847*
$\Delta(\text{Inflation})_{t-1}$	-3.575	-4.192***	$\Delta(\text{Inflation})_t$	-1.654	-5.944***
$\Delta(\text{Inflation})_{t-4}$	2.021	2.511**	$\Delta(\text{Inflation})_{t-1}$	-0.940	-3.487***
S3(seasonal dummy, q3)	0.200	3.496***	$\Delta(\text{Inflation})_{t-2}$	-0.698	-2.590**
S4(seasonal dummy, q4)	0.259	4.182***	S4(seasonal dummy, q4)	0.028	2.021*
D1(2008q4)	0.627	8.265***	Constant	-0.014	-1.943*
Constant	-0.101	-3.719***			
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	0.155 (4.514)**		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	1.316 (6.349)**	
Diagnostics					
Adjusted R^2	0.87		Adjusted R^2	0.63	
Serial Correlation (4 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.234		LM Test (chi-square)	0.150	
F-Test	0.501		F-Test	0.283	
Heteroscedasticity	0.212		Heteroscedasticity	0.928	
Normality	0.749		Normality	0.508	
Ramsey RESET	0.230		Ramsey RESET	0.777	
Sample Information					
Sample size (adjusted)	1999q1-2010q2		Sample size (adjusted)	1998q1-2010q2	
Observations	46		Observations	50	

Hungary

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.035	1.243	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.015	0.239
$\Delta\text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	0.077	2.720***	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	0.195	3.225***
$\Delta\ln(\text{Real GDP})_{t-1}$	0.641	1.980*	$\Delta\text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	-0.115	-1.946*
$\Delta\ln(\text{Real GDP})_{t-2}$	0.806	2.417**	$\Delta\ln(\text{Real GDP})_{t-2}$	0.365	2.224**
$\Delta\ln(\text{Real GDP})_{t-3}$	0.855	2.363**	$\Delta\ln(\text{Real GDP})_{t-3}$	1.090	6.798***
$\Delta\text{Interest Rate}_t$	0.008	1.732*	$\Delta\ln(\text{Real GDP})_{t-4}$	-0.680	-3.858***
$\Delta\ln(\text{REER})_t$	-0.570	-3.697***	$\Delta\text{Interest Rate}_t$	-0.004	-1.782*
$\Delta\ln(\text{REER})_{t-2}$	0.740	4.474***	$\Delta\ln(\text{REER})_t$	-0.215	-2.908***
$\Delta\ln(\text{REER})_{t-4}$	0.462	3.218***	S2(seasonal dummy, q2)	0.234	5.632***
$\Delta(\text{Inflation})_{t-3}$	-0.842	-1.962*	S3(seasonal dummy, q3)	0.284	6.440***
$\Delta(\text{Inflation})_{t-4}$	0.742	1.904*	S4(seasonal dummy, q4)	0.411	7.911***
AR(1)	-0.248	-2.490**	Constant	-0.224	-7.272***
S2(seasonal dummy, q2)	0.189	3.164***			
S3(seasonal dummy, q3)	0.187	3.028***			
S4(seasonal dummy, q4)	0.260	3.234***			
D1(2001q1)	-0.170	-5.489***			
Constant	-0.169	-5.436***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.090 (8.381)***		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.095 (0.890)	
Diagnostics					
Adjusted R^2	0.86		Adjusted R^2	0.81	
Serial Correlation (8 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.098*		LM Test (chi-square)	0.248	
F-Test	0.306		F-Test	0.340	
Heteroscedasticity	0.157		Heteroscedasticity	0.449	
Normality	0.989		Normality	0.339	
Ramsey RESET	0.958		Ramsey RESET	0.512	
Sample Information					
Sample size (adjusted)	1996q1-2010q2		Sample size (adjusted)	1996q2-2010q2	
Observations	58		Observations	57	

India

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	0.157	2.860***	ΔReal FXR_t/Real BM_{t-1}	0.288	1.960*
ΔReal FXR_{t-2}/Real RM_{t-3}	0.155	2.870***	ΔReal FXR_{t-1}/Real BM_{t-2}	-0.499	-3.017***
$\Delta\ln(\text{Real GDP})_t$	0.737	5.260***	ΔReal FXR_{t-2}/Real BM_{t-3}	0.463	2.963***
$\Delta\ln(\text{Real GDP})_{t-1}$	0.368	6.822***	ΔReal FXR_{t-3}/Real BM_{t-4}	-0.425	-2.505**
$\Delta\ln(\text{Real GDP})_{t-2}$	0.328	2.322**	ΔReal FXR_{t-4}/Real BM_{t-5}	0.377	2.449**
$\Delta\ln(\text{REER})_{t-2}$	0.257	1.770*	$\Delta\ln(\text{Real GDP})_{t-1}$	0.118	3.640***
$\Delta(\text{Inflation})_t$	-0.506	-2.785***	$\Delta\ln(\text{Real GDP})_{t-2}$	0.199	3.942***
AR(1)	-0.438	-4.366***	$\Delta\ln(\text{Real GDP})_{t-4}$	0.161	3.729***
S2(seasonal dummy, q2)	0.052	1.787*	$\Delta\ln(\text{REER})_{t-1}$	-0.144	-1.796*
S4(seasonal dummy, q4)	-0.076	-2.701***	$\Delta\ln(\text{REER})_{t-2}$	0.214	2.710***
Constant	0.000	0.023	$\Delta(\text{Inflation})_t$	-0.610	-5.354***
			AR(4)	0.315	2.687**
			Constant	0.008	2.482**
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	0.216 (22.625)***		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	0.297 (1.092)	
Diagnostics					
Adjusted R^2	0.80		Adjusted R^2	0.76	
Serial Correlation (2 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.828		LM Test (chi-square)	0.217	
F-Test	0.866		F-Test	0.450	
Heteroscedasticity	0.549		Heteroscedasticity	0.172	
Normality	0.279		Normality	0.915	
Ramsey RESET	0.030**		Ramsey RESET	0.543	
Sample Information					
Sample size (adjusted)	1997q1-2010q2		Sample size (adjusted)	1997q3-2010q2	
Observations	54		Observations	52	

Indonesia

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.100	-1.316	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.440	2.334**
$\Delta\ln(\text{Real GDP})_{t-3}$	1.272	4.903***	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-0.441	-2.044*
$\Delta\ln(\text{Real GDP})_{t-4}$	-0.570	-1.807*	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	0.748	4.080***
$\Delta\text{Interest Rate}_t$	-0.017	-3.866***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.851	7.704***
$\Delta\ln(\text{REER})_t$	-0.176	-2.398**	$\Delta\ln(\text{Real GDP})_{t-2}$	0.275	1.976*
$\Delta\ln(\text{REER})_{t-3}$	-0.148	-1.960*	$\Delta\ln(\text{Real GDP})_{t-3}$	0.573	4.484***
$\Delta(\text{Inflation})_{t-1}$	0.626	2.193**	$\Delta\ln(\text{Real GDP})_{t-4}$	0.483	4.412***
$\Delta(\text{Inflation})_{t-2}$	-0.545	-2.819***	$\Delta\text{Interest Rate}_{t-2}$	0.005	3.130***
AR(1)	-0.290	-4.384***	$\Delta\text{Interest Rate}_{t-3}$	0.009	4.455***
AR(3)	0.183	2.094**	$\Delta\text{Interest Rate}_{t-4}$	0.006	4.401***
AR(4)	0.307	3.876***	$\Delta\ln(\text{REER})_t$	-0.232	-9.214***
S3(seasonal dummy, q3)	0.117	5.009***	$\Delta\ln(\text{REER})_{t-1}$	-0.092	-2.330**
S4(seasonal dummy, q4)	0.144	6.426***	$\Delta\ln(\text{REER})_{t-2}$	-0.167	-5.076***
D1(1996q1)	0.203	3.966***	$\Delta\ln(\text{REER})_{t-3}$	-0.220	-4.496***
D2(2008q4)	-0.279	-5.162***	$\Delta\ln(\text{REER})_{t-4}$	-0.071	-1.803*
Constant	-0.049	-3.632***	$\Delta(\text{Inflation})_t$	-0.617	-4.385***
			$\Delta(\text{Inflation})_{t-2}$	-0.249	-2.110*
			$\Delta(\text{Inflation})_{t-3}$	-0.389	-3.142***
			$\Delta(\text{Inflation})_{t-4}$	-0.516	-4.201***
			AR(1)	-0.586	-12.270***
			AR(3)	-0.360	-8.615***
			AR(4)	-0.146	-3.443***
			D1(1996q1)	0.414	30.592***
			Constant	0.003	0.668
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.124 (1.712)		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.357 (5.840)***	
Diagnostics					
Adjusted R^2	0.78		Adjusted R^2	0.93	
Serial Correlation (4 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.191		LM Test (chi-square)	0.086*	
F-Test	0.348		F-Test	0.299	
Heteroscedasticity	0.786		Heteroscedasticity	0.661	
Normality	0.537		Normality	0.729	
Ramsey RESET	0.292		Ramsey RESET	0.146	
Sample Information					
Sample size (adjusted)	1995q1-2010q2		Sample size (adjusted)	1995q2-2010q2	
Observations	62		Observations	61	

Israel

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic[#]	**Explanatory variables**	Coefficient	t-statistic^
$\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$	0.563	5.714***	$\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$	0.091	0.704
$\Delta \text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	0.116	1.936*	$\Delta \text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	-0.229	-2.357**
$\Delta \text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	-0.122	-2.287**	$\Delta \ln(\text{Real GDP})_{t-1}$	0.199	1.720*
$\Delta \text{Interest Rate}_{t-3}$	-0.018	-2.821***	$\Delta \ln(\text{Real GDP})_{t-3}$	0.183	1.714*
$\Delta \text{Interest Rate}_{t-4}$	-0.015	-2.995***	$\Delta \text{Interest Rate}_{t-3}$	-0.004	-2.344**
$\Delta \ln(\text{REER})_t$	0.571	1.838*	$\Delta \ln(\text{REER})_{t-3}$	0.216	2.389**
$\Delta(\text{Inflation})_t$	-1.173	-1.874*	$\Delta(\text{Inflation})_t$	-0.783	-5.491***
$\Delta(\text{Inflation})_{t-2}$	-0.933	-1.687*	$\Delta(\text{Inflation})_{t-1}$	0.353	2.318**
AR(2)	0.191	3.810***	$\Delta(\text{Inflation})_{t-2}$	-0.485	-2.737***
S2(seasonal dummy, q2)	0.068	2.732***	$\Delta(\text{Inflation})_{t-3}$	0.410	2.529**
S3(seasonal dummy, q3)	0.076	3.412***	$\Delta(\text{Inflation})_{t-4}$	-0.610	-3.046***
S4(seasonal dummy, q4)	0.087	3.905***	AR(1)	0.378	6.700***
D1(2008q4)	0.467	11.729***	AR(2)	-0.258	-3.832***
Constant	-0.078	-4.041***	AR(3)	0.223	3.343***
			AR(4)	-0.181	-3.039***
			S2(seasonal dummy, q2)	-0.031	-7.037***
			S4(seasonal dummy, q4)	-0.017	-4.092***
			D1(1991q4)	0.201	20.169***
			Constant	0.023	4.920***
Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.688 (26.408)***		Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	-0.164 (0.994)	
Diagnostics					
Adjusted R^2	0.76		Adjusted R^2	0.75	
Serial Correlation (8 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.201		LM Test (chi-square)	0.028**	
F-Test	0.342		F-Test	0.065*	
Heteroscedasticity	0.099*		Heteroscedasticity	0.900	
Normality	0.438		Normality	0.928	
Ramsey RESET	0.213		Ramsey RESET	0.387	
Sample Information					
Sample size (adjusted)	1990q4-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	79		Observations	77	

Japan

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic^
$\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$	0.425	2.092**	$\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$	-0.455	-1.239
$\Delta \ln(\text{Real GDP})_t$	-1.281	-2.735***	$\Delta \text{Interest Rate}_{t-2}$	-0.008	-2.656***
$\Delta \ln(\text{REER})_t$	-0.221	-2.653***	$\Delta \text{Interest Rate}_{t-4}$	-0.004	-1.982*
AR(1)	-0.216	-4.166***	$\Delta(\text{Inflation})_t$	-0.697	-4.291***
AR(2)	0.263	4.681***	$\Delta(\text{Inflation})_{t-4}$	-0.315	-2.152**
AR(3)	0.286	4.468***	AR(2)	-0.112	-2.657***
S2(seasonal dummy, q2)	-0.042	-3.527***	S2(seasonal dummy, q2)	0.006	3.049***
S4(seasonal dummy, q4)	0.085	5.273***	S4(seasonal dummy, q4)	0.019	11.498***
D1(1999q4)	0.424	30.416***	D1(1998q2)	-0.086	-26.743***
D2(2000q2)	-0.318	-13.169***	D2(2004q1)	0.009	1.832*
D3(2002q1)	0.160	16.729***	Constant	-0.002	-1.303
D4(2002q2)	-0.113	-8.779***			
D5(2004q1)	-0.063	-2.668***			
Constant	-0.005	-1.071			
Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.636 (4.612)***		Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	-0.409 (1.529)	
Diagnostics					
Adjusted R^2	0.88		Adjusted R^2	0.83	
Serial Correlation (2 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.015**		LM Test (chi-square)	0.010***	
F-Test	0.028**		F-Test	0.014**	
Heteroscedasticity	0.852		Heteroscedasticity	0.804	
Normality	0.101		Normality	0.046**	
Ramsey RESET	0.415		Ramsey RESET	0.057*	
Sample Information					
Sample size (adjusted)	1990q2-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	81		Observations	77	

Korea

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.086	-2.510	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.048	0.290
$\Delta\ln(\text{Real GDP})_{t-2}$	-0.582	-2.061	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-0.319	-1.953*
$\Delta\ln(\text{Real GDP})_{t-4}$	0.469	3.953	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.414	2.224**
$\Delta\text{Interest Rate}_{t-2}$	-0.039	-3.897	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	-0.694	-3.628***
$\Delta\text{Interest Rate}_{t-4}$	-0.016	-1.815	$\Delta\ln(\text{Real GDP})_t$	0.048	2.154**
$\Delta\ln(\text{REER})_{t-2}$	-0.289	-2.069	$\Delta\ln(\text{Real GDP})_{t-1}$	0.045	2.601**
$\Delta(\text{Inflation})_{t-3}$	-1.309	-1.677	$\Delta\text{Interest Rate}_t$	0.005	3.407***
AR(1)	-0.444	-4.203	$\Delta\text{Interest Rate}_{t-3}$	-0.006	-4.969***
AR(2)	-0.227	-2.123	$\Delta\ln(\text{REER})_{t-1}$	-0.056	-1.945*
S2(seasonal dummy, q2)	-0.097	-4.147	$\Delta(\text{Inflation})_t$	-0.676	-4.715***
S3(seasonal dummy, q3)	-0.132	-2.173	AR(4)	0.267	2.913***
Constant	0.087	4.139	Constant	0.013	4.844***
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.051 (6.119)**		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	-0.752 (5.479)***	
Diagnostics					
Adjusted R^2	0.45		Adjusted R^2	0.47	
Serial Correlation (8 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.279		LM Test (chi-square)	0.010***	
F-Test	0.416		F-Test	0.019**	
Heteroscedasticity	0.631		Heteroscedasticity	0.467	
Normality	0.684		Normality	0.812	
Ramsey RESET	0.249		Ramsey RESET	0.442	
Sample Information					
Sample size (adjusted)	1991q1-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	78		Observations	81	

Malaysia

Dependent variable (Real Base Money Growth)			**Dependent variable (Real Broad Money Growth)**		
$\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$	0.041	2.153**	$\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$	0.201	3.935***
$\Delta \text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	0.044	2.120**	$\Delta \text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	-0.167	-2.748***
$\Delta \ln(\text{Real GDP})_t$	1.005	5.111***	$\Delta \ln(\text{Real GDP})_t$	0.299	4.688***
$\Delta \ln(\text{Real GDP})_{t-2}$	1.375	4.651***	$\Delta \ln(\text{Real GDP})_{t-1}$	0.230	3.048***
$\Delta \text{Interest Rate}_t$	0.032	2.346**	$\Delta \ln(\text{Real GDP})_{t-2}$	0.339	6.331***
$\Delta \text{Interest Rate}_{t-2}$	-0.043	-3.343***	$\Delta \ln(\text{Real GDP})_{t-3}$	0.170	3.300***
$\Delta \text{Interest Rate}_{t-3}$	0.039	2.809***	$\Delta \text{Interest Rate}_{t-3}$	0.011	3.333***
$\Delta \text{Interest Rate}_{t-4}$	-0.033	-2.654***	$\Delta(\text{Inflation})_t$	-0.676	-4.020***
$\Delta \ln(\text{REER})_{t-1}$	0.363	1.789*	$\Delta(\text{Inflation})_{t-1}$	-0.438	-2.435**
$\Delta \ln(\text{REER})_{t-3}$	1.112	5.196***	$\Delta(\text{Inflation})_{t-2}$	0.379	2.084**
$\Delta \ln(\text{REER})_{t-4}$	-0.530	-2.436**	AR(4)	0.191	2.141**
AR(1)	-0.176	-2.056**	S2(seasonal dummy, q2)	-0.013	-1.745*
AR(4)	0.173	2.265**	Constant	0.006	1.743*
S3(seasonal dummy, q3)	0.058	2.521**			
Constant	-0.042	-3.548***			
Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.084 (7.713)***		Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.042 (0.187)	
Diagnostics					
Adjusted R^2	0.65		Adjusted R^2	0.61	
Serial Correlation (4 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.622		LM Test (chi-square)	0.250	
F-Test	0.722		F-Test	0.143	
Heteroscedasticity	0.650		Heteroscedasticity	0.131	
Normality	0.135		Normality	0.969	
Ramsey RESET	0.003***		Ramsey RESET	0.621	
Sample Information					
Sample size (adjusted)	1990q2-2010q2		Sample size (adjusted)	1990q4-2010q2	
Observations	81		Observations	79	

Mexico

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	-0.062	-3.231***	ΔReal FXR_t/Real BM_{t-1}	-0.225	-2.092**
$\Delta\ln(\text{Real GDP})_{t-3}$	-0.700	-3.694***	ΔReal FXR_{t-3}/Real BM_{t-4}	0.293	2.182**
$\Delta\ln(\text{Real GDP})_{t-4}$	0.586	3.039***	ΔReal FXR_{t-4}/Real BM_{t-5}	-0.299	-1.996*
ΔInterest Rate_t	-0.005	-5.112***	$\Delta\ln(\text{Real GDP})_{t-1}$	-0.283	-3.202***
ΔInterest Rate_{t-1}	-0.005	-5.084***	$\Delta\ln(\text{Real GDP})_{t-4}$	0.383	5.948***
ΔInterest Rate_{t-2}	-0.004	-3.893***	ΔInterest Rate_t	-0.004	-4.782***
ΔInterest Rate_{t-4}	0.005	3.567***	ΔInterest Rate_{t-2}	0.002	2.662***
$\Delta\ln(\text{REER})_{t-4}$	0.321	3.548***	ΔInterest Rate_{t-3}	0.002	3.316***
$\Delta(\text{Inflation})_{t-4}$	-0.404	-2.427**	ΔInterest Rate_{t-4}	0.002	2.530**
AR(1)	-0.535	-7.711***	$\Delta\ln(\text{REER})_t$	-0.189	-4.854***
AR(2)	-0.160	-2.189**	$\Delta\ln(\text{REER})_{t-2}$	0.097	2.051**
AR(4)	0.361	6.684***	$\Delta(\text{Inflation})_t$	-0.422	-2.965***
S2(seasonal dummy, q2)	-0.152	-5.674***	$\Delta(\text{Inflation})_{t-1}$	-0.414	-2.467**
S3(seasonal dummy, q3)	-0.108	-5.247***	$\Delta(\text{Inflation})_{t-4}$	-0.349	-4.548***
D1(1999q4)	0.208	6.844***	AR(1)	-0.418	-5.023***
Constant	0.095	7.919***	S2(seasonal dummy, q2)	-0.042	-8.290***
			D1(1992q1)	-0.050	-3.665***
			D2(1992q2)	-0.059	-4.188***
			D3(2000q4)	-0.044	-3.376***
			Constant	0.034	11.907***
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	-0.046 (10.667)***		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	-0.164 (0.876)	
Diagnostics					
Adjusted R^2	0.97		Adjusted R^2	0.83	
Serial Correlation (8 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.007***		LM Test (chi-square)	0.351	
F-Test	0.023**		F-Test	0.468	
Heteroscedasticity	0.830		Heteroscedasticity	0.833	
Normality	0.054*		Normality	0.163	
Ramsey RESET	0.493		Ramsey RESET	0.945	
Sample Information					
Sample size (adjusted)	1991q2-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	77		Observations	77	

New Zealand

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	0.046	1.497	ΔReal FXR_t/Real BM_{t-1}	0.233	1.537
ΔReal FXR_{t-1}/Real RM_{t-2}	0.069	2.376**	ΔReal FXR_{t-3}/Real BM_{t-4}	0.518	3.598***
ΔReal FXR_{t-2}/Real RM_{t-3}	0.072	2.431**	$\Delta\ln(\text{Real GDP})_{t-3}$	-0.374	-1.798*
ΔReal FXR_{t-3}/Real RM_{t-4}	0.091	3.487***	$\Delta\ln(\text{REER})_{t-1}$	0.145	2.675***
ΔInterest Rate_t	0.067	2.741***	$\Delta\ln(\text{REER})_{t-4}$	0.121	2.152**
$\Delta\ln(\text{REER})_t$	-0.867	-2.390**	$\Delta(\text{Inflation})_{t-2}$	-0.805	-2.481**
$\Delta\ln(\text{REER})_{t-2}$	-1.291	-3.944***	$\Delta(\text{Inflation})_{t-3}$	0.634	2.176**
$\Delta(\text{Inflation})_t$	-6.492	-2.657**	AR(1)	-0.263	-2.630**
$\Delta(\text{Inflation})_{t-3}$	3.937	2.524**	AR(4)	-0.252	-2.423**
$\Delta(\text{Inflation})_{t-4}$	-3.431	-1.972*	S4(seasonal dummy, q4)	0.010	2.206**
S3(seasonal dummy, q3)	0.123	4.732***	Constant	0.019	6.298***
S4(seasonal dummy, q4)	0.273	10.154***			
D1(1999q4)	0.566	5.978***			
D2(2000q1)	-0.381	-4.111***			
D3(2008q4)	-0.191	-1.819*			
Constant	-0.068	-4.619***			
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	0.278 (18.260)***		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	0.496 (12.851)***	

Diagnostics			
Adjusted R^2	0.74	Adjusted R^2	0.27
Serial Correlation (4 lags)		Serial Correlation (2 lags)	
LM Test (chi-square)	0.242	LM Test (chi-square)	0.240
F-Test	0.370	F-Test	0.298
Heteroscedasticity	0.351	Heteroscedasticity	0.114
Normality	0.000***	Normality	0.571
Ramsey RESET	0.139	Ramsey RESET	0.721
Sample Information			
Sample size (adjusted)	1991q2-2010q2	Sample size (adjusted)	1991q2-2010q2
Observations	77	Observations	77

Norway

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta \text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta \text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic[#]
$\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$	0.034	0.779	$\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$	0.296	4.451***
$\Delta \ln(\text{Real GDP})_{t-2}$	1.978	2.611**	$\Delta \text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	0.232	3.241***
$\Delta \ln(\text{Real GDP})_{t-3}$	2.779	3.354***	$\Delta \text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.164	3.236***
$\Delta \ln(\text{Real GDP})_{t-4}$	1.831	4.808***	$\Delta \text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	0.225	4.170***
$\Delta \text{Interest Rate}_{t-1}$	-0.058	-2.508**	$\Delta \text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	0.122	2.225**
$\Delta \ln(\text{REER})_{t-2}$	-1.065	-1.781*	$\Delta \ln(\text{Real GDP})_t$	-0.155	-2.204**
$\Delta \ln(\text{REER})_{t-3}$	1.919	3.254***	$\Delta \text{Interest Rate(M)}_t$	0.010	3.654***
$\Delta (\text{Inflation})_{t-3}$	-7.623	-4.195***	$\Delta \text{Interest Rate(M)}_{t-3}$	0.012	4.510***
AR(1)	-0.381	-5.908***	$\Delta \text{Interest Rate(B)}_t$	0.015	4.489***
S2(seasonal dummy, q2)	-0.177	-2.284**	$\Delta (\text{Inflation})_t$	-1.034	-4.756***
S3(seasonal dummy, q3)	-0.182	-2.404**	S3(seasonal dummy, q3)	-0.022	-6.440***
D1(1994q4)	-0.257	-2.303***	S4(seasonal dummy, q4)	0.019	2.406**
D2(1999q4)	0.492	4.490***	D1(1991q3)	0.072	23.864***
D3(2002q1)	0.384	3.561***	D2(1992q4)	0.054	11.649***
D4(2005q3)	0.538	4.894***	D3(2000q4)	-0.046	-9.626***
D5(2007q4)	0.352	3.131***	Constant	0.013	4.420***
D6(2008q4)	0.885	7.410***			
Constant	0.046	1.628			
Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.024 (0.065)		Long-run multiplier for $\Delta \text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	1.039 (40.475)***	
Diagnostics					
Adjusted R^2	0.75		Adjusted R^2	0.68	
Serial Correlation (8 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.302		LM Test (chi-square)	0.594	
F-Test	0.522		F-Test	0.758	
Heteroscedasticity	0.679		Heteroscedasticity	0.079*	
Normality	0.103		Normality	0.437	
Ramsey RESET	0.546		Ramsey RESET	0.330	
Sample Information					
Sample size (adjusted)	1991q1-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	78		Observations	81	

Peru

Dependent variable (Real Base Money Growth)			**Dependent variable (Real Broad Money Growth)**		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.030	3.120***	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.226	3.883***
$\Delta\text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	0.057	4.391***	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.191	3.028***
$\Delta\text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	0.050	4.934***	$\Delta\text{Real FXR}_{t-4}/\text{Real BM}_{t-5}$	0.152	3.124***
$\Delta\text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	0.046	4.036***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.351	2.766***
$\Delta\ln(\text{Real GDP})_{t-1}$	0.518	2.970***	$\Delta\ln(\text{Real GDP})_{t-3}$	-0.451	-4.805***
$\Delta\ln(\text{Real GDP})_{t-3}$	-0.513	-4.095***	$\Delta\text{Interest Rate}_{t-3}$	0.007	1.732*
$\Delta\ln(\text{Real GDP})_{t-4}$	-0.376	-2.211**	$\Delta\ln(\text{REER})_t$	-0.547	-3.739***
$\Delta\text{Interest Rate}_t$	0.012	1.814*	$\Delta\ln(\text{REER})_{t-1}$	0.297	2.021*
$\Delta\text{Interest Rate}_{t-1}$	-0.027	-4.015***	$\Delta\ln(\text{REER})_{t-3}$	0.229	1.970*
$\Delta\text{Interest Rate}_{t-2}$	0.031	5.259***	$\Delta\ln(\text{REER})_{t-4}$	-0.378	-2.928***
$\Delta\text{Interest Rate}_{t-3}$	-0.019	-3.802***	$\Delta(\text{Inflation})_{t-1}$	-1.043	-3.298***
$\Delta\ln(\text{REER})_t$	-0.842	-5.822***	S2(seasonal dummy, q2)	-0.074	-6.120***
$\Delta\ln(\text{REER})_{t-1}$	0.829	4.853***	S3(seasonal dummy, q3)	-0.070	-3.688***
$\Delta\ln(\text{REER})_{t-2}$	-0.581	-3.848***	Constant	0.049	6.733***
$\Delta\ln(\text{REER})_{t-4}$	-0.797	-5.559***			
$\Delta(\text{Inflation})_{t-1}$	-1.644	-4.013***			
$\Delta(\text{Inflation})_{t-3}$	-0.702	-1.881*			
$\Delta(\text{Inflation})_{t-4}$	1.010	3.018***			
AR(2)	-0.229	-2.714***			
AR(3)	-0.288	-3.791***			
S2(seasonal dummy, q2)	0.091	2.747***			
S4(seasonal dummy, q4)	0.204	7.754***			
D1(1996q4)	-0.161	-5.980***			
D2(1997q2)	-0.102	-4.379***			
Constant	-0.038	-2.531**			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.120 (86.527)***		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.569 (51.928)***	
Diagnostics					
Adjusted R^2	0.96		Adjusted R^2	0.60	
Serial Correlation (2 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.107		LM Test (chi-square)	0.188	
F-Test	0.275		F-Test	0.281	
Heteroscedasticity	0.385		Heteroscedasticity	0.670	
Normality	0.550		Normality	0.260	
Ramsey RESET	0.972		Ramsey RESET	0.032**	
Sample Information					
Sample size (adjusted)	1995q2-2010q2		Sample size (adjusted)	1995q2-2010q2	
Observations	61		Observations	61	

Philippines

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.076	-1.983*	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.042	0.246
$\Delta\ln(\text{Real GDP})_{t-1}$	0.304	3.255***	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.283	1.814*
$\Delta\ln(\text{Real GDP})_{t-4}$	-0.423	-6.908***	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	0.375	2.297**
$\Delta\ln(\text{REER})_{t-2}$	0.433	2.281**	$\Delta\ln(\text{REER})_t$	-0.220	-1.847*
S4(seasonal dummy, q4)	0.201	9.665***	$\Delta\ln(\text{REER})_{t-1}$	0.190	1.656
D1(1999q4)	0.248	13.325***	$\Delta(\text{Inflation})_t$	-0.634	-2.564**
D2(2006q4)	0.334	26.615***	$\Delta(\text{Inflation})_{t-3}$	0.833	3.418***
Constant	-0.033	-4.733***	AR(4)	0.498	6.727***
			S4(seasonal dummy, q4)	0.038	2.856***
			Constant	-0.004	-0.777
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	-0.076 (3.932)*		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	1.396 (4.171)**	
Diagnostics					
Adjusted R^2	0.85		Adjusted R^2	0.73	
Serial Correlation (2 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.027**		LM Test (chi-square)	0.107	
F-Test	0.037**		F-Test	0.154	
Heteroscedasticity	0.611		Heteroscedasticity	0.043**	
Normality	0.520		Normality	0.201	
Ramsey RESET	0.935		Ramsey RESET	0.476	
Sample Information					
Sample size (adjusted)	1990q2-2010q2		Sample size (adjusted)	1991q1-2010q2	
Observations	81		Observations	78	

Poland

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	-0.011	-0.142	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.007	0.070
$\Delta\text{Real FXR}_{t-3}/\text{Real RM}_{t-4}$	0.149	1.710*	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	-0.280	-2.268**
$\Delta\ln(\text{Real GDP})_t$	0.910	4.765***	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.275	2.746***
$\Delta\ln(\text{Real GDP})_{t-4}$	-0.684	-3.332***	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	0.365	3.806***
$\Delta\text{Interest Rate}_{t-1}$	-0.039	-5.320***	$\Delta\ln(\text{Real GDP})_t$	0.750	5.764***
$\Delta\text{Interest Rate}_{t-2}$	0.048	5.371***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.343	4.289***
$\Delta(\text{Inflation})_{t-2}$	2.578	3.114***	$\Delta\ln(\text{Real GDP})_{t-4}$	-0.720	-8.157***
$\Delta(\text{Inflation})_{t-3}$	-2.208	-2.189**	$\Delta\text{Interest Rate}_t$	-0.018	-5.424***
AR(1)	-0.221	-2.160**	$\Delta\text{Interest Rate}_{t-1}$	0.018	6.537***
S2(seasonal dummy, q2)	0.028	2.032**	$\Delta\text{Interest Rate}_{t-4}$	-0.006	-2.882***
D1(2001q4)	0.175	5.625***	$\Delta\ln(\text{REER})_t$	-0.068	-1.745*
D2(2008q4)	0.124	4.494***	$\Delta(\text{Inflation})_t$	-0.641	-3.041***
Constant	0.000	0.005	$\Delta(\text{Inflation})_{t-2}$	0.864	3.577***
			AR(2)	0.385	4.848***
			AR(3)	0.312	3.843***
			S2(seasonal dummy, q2)	0.082	4.240***
			S3(seasonal dummy, q3)	0.041	3.619***
			S4(seasonal dummy, q4)	0.055	2.840***
			Constant	-0.048	-3.773***
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.113 (1.166)		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	1.211 (3.216)*	
Diagnostics					
Adjusted R^2	0.67		Adjusted R^2	0.84	
Serial Correlation (2 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.008***		LM Test (chi-square)	0.078*	
F-Test	0.024**		F-Test	0.210	
Heteroscedasticity	0.893		Heteroscedasticity	0.616	
Normality	0.633		Normality	0.916	
Ramsey RESET	0.357		Ramsey RESET	0.897	
Sample Information					
Sample size (adjusted)	1997q3-2010q2		Sample size (adjusted)	1998q1-2010q2	
Observations	52		Observations	50	

Russia

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.264	3.041***	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.292	5.938***
$\Delta\text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	0.083	1.720*	$\Delta\text{Real FXR}_{t-2}/\text{Real BM}_{t-3}$	0.199	3.406***
$\Delta\text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	-0.094	-2.093**	$\Delta\ln(\text{Real GDP})_{t-2}$	-0.077	-1.855*
$\Delta\ln(\text{Real GDP})_{t-3}$	-0.740	-5.622***	$\Delta\ln(\text{Real GDP})_{t-3}$	-0.177	-1.844*
$\Delta\text{Interest Rate}_t$	0.007	4.172***	$\Delta\text{Interest Rate}_{t-4}$	0.002	3.381***
$\Delta\text{Interest Rate}_{t-1}$	-0.008	-6.440***	$\Delta\ln(\text{REER})_t$	0.128	2.226**
$\Delta\text{Interest Rate}_{t-2}$	0.005	4.194***	$\Delta(\text{Inflation})_t$	-0.316	-5.769***
$\Delta\text{Interest Rate}_{t-3}$	-0.003	-3.364***	$\Delta(\text{Inflation})_{t-2}$	-0.155	-2.158**
$\Delta\text{Interest Rate}_{t-4}$	0.004	5.957***	$\Delta(\text{Inflation})_{t-3}$	0.113	1.816*
$\Delta\ln(\text{REER})_{t-1}$	-0.234	-6.014***	AR(2)	-0.315	-2.896***
$\Delta\ln(\text{REER})_{t-4}$	0.323	3.649***	AR(3)	0.361	4.124***
$\Delta(\text{Inflation})_t$	-0.623	-8.506***	S2(seasonal dummy, q2)	0.088	5.870***
S2(seasonal dummy, q2)	0.220	6.248***	S4(seasonal dummy, q4)	0.086	4.453***
S4(seasonal dummy, q4)	0.098	3.511***	Constant	-0.021	-3.152***
Constant	-0.052	-7.424***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.253 (10.548)***		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.515 (59.747)***	
Diagnostics					
Adjusted R^2	0.80		Adjusted R^2	0.87	
Serial Correlation (2 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.003***		LM Test (chi-square)	0.035**	
F-Test	0.011**		F-Test	0.112	
Heteroscedasticity	0.869		Heteroscedasticity	0.534	
Normality	0.957		Normality	0.739	
Ramsey RESET	0.519		Ramsey RESET	0.259	
Sample Information					
Sample size (adjusted)	1996q3-2010q2		Sample size (adjusted)	1996q2-2010q2	
Observations	56		Observations	57	

South Africa

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{\text{res},t}/\text{Real RM}_{\text{res},t-1}$			$\Delta\text{Real BM}_{\text{br},t}/\text{Real BM}_{\text{br},t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.057	1.085	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	-0.020	-0.076
$\Delta\text{Real FXR}_{t-1}/\text{Real RM}_{t-2}$	0.088	1.939*	$\Delta\text{Real FXR}_{t-1}/\text{Real BM}_{t-2}$	0.875	3.198***
$\Delta\ln(\text{Real GDP})_{t-1}$	1.493	2.194**	$\Delta\ln(\text{Real GDP})_t$	1.532	4.071***
$\Delta\ln(\text{Real GDP})_{t-3}$	1.811	2.809***	$\Delta\ln(\text{Real GDP})_{t-1}$	-1.117	-2.387**
$\Delta\ln(\text{REER})_t$	-0.275	-3.588***	$\Delta\ln(\text{Real GDP})_{t-2}$	1.731	5.041***
$\Delta\ln(\text{REER})_{t-2}$	-0.265	-3.459***	$\Delta\text{Interest Rate}_{t-4}$	0.005	2.303**
$\Delta\ln(\text{REER})_{t-4}$	-0.182	-2.333**	$\Delta\ln(\text{REER})_{t-1}$	-0.092	-2.529**
$\Delta(\text{Inflation})_t$	-1.869	-4.618***	$\Delta\ln(\text{REER})_{t-3}$	-0.101	-2.923***
$\Delta(\text{Inflation})_{t-1}$	-1.181	-3.411***	$\Delta\ln(\text{REER})_{t-4}$	0.097	2.640***
$\Delta(\text{Inflation})_{t-4}$	-1.332	-3.456***	$\Delta(\text{Inflation})_t$	-0.549	-3.111***
AR(1)	-0.401	-5.953***	AR(3)	-0.186	-2.051**
AR(2)	-0.317	-4.741***	AR(4)	0.217	2.176**
S4(seasonal dummy, q4)	0.096	10.193***	S2(seasonal dummy, q2)	-0.014	-3.312***
D1(1993q4)	-0.188	-5.165***	Constant	0.002	0.519
D2(1997q2)	-0.081	-2.041**			
Constant	-0.029	-4.313***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.084 (5.144)**		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.882 (6.060)**	
Diagnostics					
Adjusted R^2	0.72		Adjusted R^2	0.59	
Serial Correlation (4 lags)			Serial Correlation (4 lags)		
LM Test (chi-square)	0.347		LM Test (chi-square)	0.336	
F-Test	0.484		F-Test	0.448	
Heteroscedasticity	0.909		Heteroscedasticity	0.934	
Normality	0.624		Normality	0.296	
Ramsey RESET	0.369		Ramsey RESET	0.573	
Sample Information					
Sample size (adjusted)	1991q2-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	77		Observations	81	

Singapore

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.008	0.780	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.169	2.656***
$\Delta\text{Real FXR}_{t-2}/\text{Real RM}_{t-3}$	0.030	2.594**	$\Delta\text{Interest Rate}_{t-1}$	-0.005	-2.318**
$\Delta\text{Real FXR}_{t-4}/\text{Real RM}_{t-5}$	0.041	3.460***	$\Delta(\text{Inflation})_t$	-0.977	-4.515***
$\Delta\ln(\text{Real GDP})_{t-1}$	-0.255	-2.036**	AR(1)	0.254	2.826***
$\Delta\ln(\text{Real GDP})_{t-2}$	-0.472	-3.293***	AR(4)	0.293	3.007***
$\Delta\ln(\text{Real GDP})_{t-3}$	-0.275	-2.202**	S2(seasonal dummy, q2)	-0.009	-2.262**
$\Delta\text{Interest Rate}_{t-1}$	-0.016	-2.174**	S3(seasonal dummy, q3)	-0.011	-2.738***
$\Delta\ln(\text{REER})_{t-1}$	1.154	4.548***	Constant	0.009	2.646***
$\Delta(\text{Inflation})_{t-1}$	-1.071	-2.514**			
AR(1)	-0.576	-10.274***			
AR(2)	-0.293	-4.690***			
AR(3)	-0.183	-2.861***			
S2(seasonal dummy, q2)	-0.031	-3.362***			
S3(seasonal dummy, q3)	-0.031	-3.286***			
D1(1998q3)	-0.236	-10.057***			
D2(1999q4)	0.231	10.665***			
Constant	0.044	6.870***			
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.039 (14.376)***		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	0.374 (5.404)**	
Diagnostics					
Adjusted R^2	0.84		Adjusted R^2	0.43	
Serial Correlation (4 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.166		LM Test (chi-square)	0.351	
F-Test	0.246		F-Test	0.395	
Heteroscedasticity	0.677		Heteroscedasticity	0.680	
Normality	0.856		Normality	0.961	
Ramsey RESET	0.335		Ramsey RESET	0.805	
Sample Information					
Sample size (adjusted)	1990q3-2010q2		Sample size (adjusted)	1990q2-2010q2	
Observations	80		Observations	81	

Taiwan

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
$\Delta\text{Real RM}_{res,t}/\text{Real RM}_{res,t-1}$			$\Delta\text{Real BM}_{br,t}/\text{Real BM}_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic
$\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$	0.074	1.911*	$\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$	0.464	4.012***
$\Delta\ln(\text{Real GDP})_t$	-0.430	-2.383**	$\Delta\text{Real FXR}_{t-3}/\text{Real BM}_{t-4}$	-0.224	-1.950*
$\Delta\ln(\text{Real GDP})_{t-2}$	-0.351	-2.191**	$\Delta\ln(\text{Real GDP})_t$	-0.183	-5.581***
$\Delta\ln(\text{Real GDP})_{t-4}$	0.334	1.843*	$\Delta\text{Interest Rate}_{t-3}$	0.008	2.148**
$\Delta\text{Interest Rate}_{t-1}$	0.034	2.299**	$\Delta\ln(\text{NC/USD})_{t-2}$	-0.096	-2.618**
$\Delta\text{Interest Rate}_{t-3}$	0.049	3.105***	$\Delta(\text{Inflation})_t$	-0.975	-8.195***
$\Delta\text{Interest Rate}_{t-4}$	-0.061	-4.024***	$\Delta(\text{Inflation})_{t-1}$	0.252	2.503**
$\Delta\ln(\text{NC/USD})_t$	-0.290	-1.948*	$\Delta(\text{Inflation})_{t-2}$	0.216	2.040**
$\Delta\ln(\text{NC/USD})_{t-1}$	-0.418	-2.666***	$\Delta(\text{Inflation})_{t-4}$	-0.507	-4.303***
$\Delta\ln(\text{NC/USD})_{t-4}$	-0.368	-2.404**	AR(1)	0.157	2.355**
$\Delta(\text{Inflation})_{t-1}$	-0.757	-1.960*	AR(2)	0.416	4.993***
AR(1)	-0.295	-3.114***	AR(3)	0.125	2.013**
S3(seasonal dummy, q3)	-0.046	-2.247**	AR(4)	0.264	2.895***
Constant	0.026	2.965***	S4(seasonal dummy, q4)	0.029	6.456***
			Constant	-0.006	-2.395**
Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real RM}_{t-1}$ (F-statistic)	0.057 (3.678)*		Long-run multiplier for $\Delta\text{Real FXR}_t/\text{Real BM}_{t-1}$ (F-statistic)	6.272 (0.107)	
Diagnostics					
Adjusted R^2	0.38		Adjusted R^2	0.80	
Serial Correlation (8 lags)			Serial Correlation (8 lags)		
LM Test (chi-square)	0.231		LM Test (chi-square)	0.433	
F-Test	0.378		F-Test	0.619	
Heteroscedasticity	0.308		Heteroscedasticity	0.796	
Normality	0.823		Normality	0.295	
Ramsey RESET	0.443		Ramsey RESET	0.562	
Sample Information					
Sample size (adjusted)	1990q3-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	80		Observations	77	

Thailand

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic^	**Explanatory variables**	Coefficient	t-statistic
ΔReal FXR_t/Real RM_{t-1}	0.030	0.855	ΔReal FXR_t/Real BM_{t-1}	0.191	1.825*
ΔReal FXR_{t-1}/Real RM_{t-2}	-0.062	-2.049**	ΔReal FXR_{t-3}/Real BM_{t-4}	0.388	3.650***
$\Delta\ln(\text{Real GDP})_{t-1}$	0.461	3.163***	$\Delta\ln(\text{Real GDP})_t$	0.117	2.764***
$\Delta\ln(\text{Real GDP})_{t-4}$	0.877	4.426***	$\Delta\ln(\text{Real GDP})_{t-1}$	0.106	2.819***
ΔInterest Rate_t	-0.016	-2.422**	$\Delta\ln(\text{REER})_{t-1}$	-0.126	-3.710***
ΔInterest Rate_{t-2}	0.014	1.701*	$\Delta\ln(\text{REER})_{t-3}$	-0.185	-4.510***
ΔInterest Rate_{t-4}	-0.025	-3.659***	$\Delta\ln(\text{REER})_{t-4}$	-0.097	-2.669***
$\Delta\ln(\text{REER})_t$	0.420	3.295***	$\Delta(\text{Inflation})_t$	-0.913	-7.066***
$\Delta\ln(\text{REER})_{t-1}$	-0.214	-2.184**	$\Delta(\text{Inflation})_{t-3}$	0.504	3.991***
$\Delta\ln(\text{REER})_{t-2}$	0.545	4.088***	AR(4)	0.677	8.767***
$\Delta\ln(\text{REER})_{t-3}$	-0.203	-2.332**	Constant	-0.002	-1.263
$\Delta\ln(\text{REER})_{t-4}$	0.211	1.905*			
$\Delta(\text{Inflation})_t$	-0.897	-1.907*			
$\Delta(\text{Inflation})_{t-2}$	-1.969	-4.512***			
$\Delta(\text{Inflation})_{t-3}$	0.953	3.154***			
$\Delta(\text{Inflation})_{t-4}$	-1.390	-3.366***			
AR(1)	-0.393	-5.484***			
AR(2)	-0.402	-4.760***			
S2(seasonal dummy, q2)	0.049	2.085**			
S4(seasonal dummy, q4)	0.052	3.623***			
Constant	-0.009	-1.267			
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	-0.017 (0.321)		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	1.792 (9.944)***	
Diagnostics					
Adjusted R^2	0.84		Adjusted R^2	0.74	
Serial Correlation (2 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.124		LM Test (chi-square)	0.232	
F-Test	0.221		F-Test	0.290	
Heteroscedasticity	0.482		Heteroscedasticity	0.823	
Normality	0.179		Normality	0.565	
Ramsey RESET	0.307		Ramsey RESET	0.950	
Sample Information					
Sample size (adjusted)	1991q2-2010q2		Sample size (adjusted)	1991q2-2010q2	
Observations	77		Observations	77	

Turkey

Dependent variable (Real Base Money Growth)			Dependent variable (Real Broad Money Growth)		
ΔReal $RM_{res,t}$/Real $RM_{res,t-1}$			ΔReal $BM_{br,t}$/Real $BM_{br,t-1}$		
Explanatory variables	Coefficient	t-statistic	**Explanatory variables**	Coefficient	t-statistic^
ΔReal FXR_t/Real RM_{t-1}	-0.012	-0.309	ΔReal FXR_t/Real BM_{t-1}	-0.300	-3.093***
$\Delta\ln(\text{Real GDP})_{t-2}$	0.367	2.678***	ΔReal FXR_{t-1}/Real BM_{t-2}	0.433	3.502***
$\Delta\ln(\text{Real GDP})_{t-4}$	0.511	3.821***	ΔReal FXR_{t-2}/Real BM_{t-3}	-0.347	-3.440***
ΔInterest Rate_{t-1}	0.002	1.675*	$\Delta\ln(\text{Real GDP})_t$	0.170	5.199***
$\Delta\ln(\text{REER})_t$	-0.532	-5.483***	ΔInterest Rate_t	0.001	1.805*
$\Delta\ln(\text{REER})_{t-4}$	0.272	2.747***	ΔInterest Rate_{t-1}	0.002	1.955*
$\Delta(\text{Inflation})_t$	-0.513	-3.275***	ΔInterest Rate_{t-3}	0.002	3.895***
AR(1)	-0.346	-3.928***	$\Delta\ln(\text{REER})_t$	-0.310	-6.273***
AR(2)	0.352	3.066***	$\Delta\ln(\text{REER})_{t-1}$	0.137	2.101**
D1(1999q4)	0.153	3.150***	$\Delta\ln(\text{REER})_{t-2}$	0.103	2.198**
D2(2005q4)	0.165	3.273***	$\Delta\ln(\text{REER})_{t-3}$	0.163	2.283**
Constant	0.004	0.537	$\Delta(\text{Inflation})_t$	-0.218	-2.181**
			$\Delta(\text{Inflation})_{t-2}$	0.200	1.883*
			S2(seasonal dummy, q2)	-0.030	-2.970***
			D1(2005q4)	0.124	14.336***
			Constant	0.032	5.570***
Long-run multiplier for ΔReal FXR_t/Real RM_{t-1} (F-statistic)	-0.012 (0.096)		Long-run multiplier for ΔReal FXR_t/Real BM_{t-1} (F-statistic)	-0.214 (1.501)	
Diagnostics					
Adjusted R^2	0.63		Adjusted R^2	0.74	
Serial Correlation (8 lags)			Serial Correlation (2 lags)		
LM Test (chi-square)	0.554		LM Test (chi-square)	0.179	
F-Test	0.733		F-Test	0.285	
Heteroscedasticity	0.550		Heteroscedasticity	0.343	
Normality	0.391		Normality	0.875	
Ramsey RESET	0.862		Ramsey RESET	0.538	
Sample Information					
Sample size (adjusted)	1995q2-2010q2		Sample size (adjusted)	1995q1-2010q2	
Observations	61		Observations	62	

Section B: Unit Root and Stationarity Tests for Variables in Levels and First Differences

Variable	Argentina			Australia			Brazil		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-1.434 (c, t) (2)	-1.234 (c, t) (5)	0.139* (c, t) (6)	1.469 (c, t) (11)	0.019 (c, t) (4)	0.261*** (c, t) (7)	-0.740 (c, t) (7)	0.039 (c, t) (4)	0.223*** (c, t) (6)
Real RM	-1.538 (c, t) (7)	-1.567 (c, t) (6)	0.265*** (c, t)(6)	-2.727 (c, t) (8)	-5.262*** (c, t) (2)	0.094 (c, t) (5)	-1.755 (c, t) (5)	-1.791 (c, t) (0)	0.151** (c, t) (4)
Real FXR_{cb}	-3.276* (c, t) (12)	-1.699 (c, t) (5)	0.156** (c, t) (6)	-3.678** (c, t) (12)	-1.887 (c, t) (3)	0.138* (c, t) (6)	-1.078 (c, t) (6)	-1.014 (c, t) (3)	0.228*** (c, t) (6)
ln(Real GDP)	-1.463 (c, t) (8)	-2.862 (c, t) (11)	0.199** (c, t) (6)	-3.698** (c, t) (5)	-2.062 (c, t) (3)	0.130* (c, t) (6)	-1.394 (c, t) (5)	-5.059*** (c, t) (2)	0.264*** (c, t) (4)
ln(REER)	-2.894 (c, t) (1)	-2.436 (c, t) (2)	0.116 (c, t) (5)	-1.922 (c, t) (7)	-2.115 (c, t) (2)	0.259*** (c, t) (6)	-1.314 (c) (0)	-1.281 (c) (4)	0.249 (c) (6)
Inflation	-3.273* (c) (5)	-2.640* (c) (1)	0.087 (c, t) (5)	-3.857*** (c) (9)	-3.805** (c) (4)	0.079 (c) (6)	-1.826 (c) (9)	-2.950** (c) (2)	0.110 (c, t) (5)
IntRate(M)	-3.503** (c) (3)	-3.880*** (c) (2)	0.095 (c) (5)	-3.318* (c, t) (8)	-2.532 (c) (3)	0.228** (c, t) (6)	-2.300 (c, t) (8)	-5.464*** (c, t) (6)	0.072 (c, t) (3)
IntRate(B)	-	-	-	-3.416* (c, t) (10)	-2.919** (c) (1)	0.215*** (c, t) (6)	-	-	-
First Difference									
$\Delta\text{Real BM}_t/\text{Real BM}_{t-1}$	-3.916*** (c) (1)	-6.911*** (c) (4)	0.162 (c) (5)	-3.077** (c) (4)	-7.720*** (c) (1)	0.329 (c) (2)	-3.198** (c) (5)	-6.855*** (c) (5)	0.198 (c) (1)
$\Delta\text{Real RM}_t/\text{Real RM}_{t-1}$	-3.159** (c) (6)	-12.003*** (c) (1)	0.087 (c) (7)	-3.085** (c) (7)	-11.543*** (-) (26)	0.167 (c) (30)	-3.655*** (c) (4)	-8.468*** (c) (6)	0.082 (c) (5)
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-4.057*** (c) (1)	-8.475*** (c) (4)	0.087 (c) (4)	-1.710 (c) (10)	-8.392*** (c) (1)	0.098 (c) (0)	-4.087** (c, t) (9)	-7.896*** (c, t) (1)	0.059 (c, t) (1)
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-1.545 (-) (11)	-7.822*** (-) (3)	0.111 (c) (4)	-8.495*** (c) (0)	-8.491*** (c) (1)	0.102 (c) (1)	-3.799** (c, t) (9)	-8.002*** (c, t) (1)	0.056 (c, t) (1)
Δln(Real GDP)	-2.192 (c) (8)	-13.845*** (c) (10)	0.180 (c) (19)	-3.169* (c, t) (12)	-8.268*** (c) (3)	0.140 (c) (3)	-3.758** (c, t) (8)	-17.461*** (c) (15)	0.157 (c) (15)
Δln(REER)	-5.867*** (-) (1)	-5.827*** (-) (7)	0.071 (c) (5)	-3.048*** (-) (6)	-7.459*** (-) (4)	0.036 (c, t) (4)	-7.332*** (-) (0)	-7.324*** (-) (7)	0.232 (c) (6)
Δ(Inflation)	-4.049*** (-) (5)	3.620*** (-) (5)	0.101 (c) (0)	-3.696*** (-) (11)	-7.377*** (-) (3)	0.162 (c) (4)	-3.186*** (-) (4)	-3.993*** (-) (5)	0.115 (c) (1)
ΔIntRate(M)	-5.170*** (-) (2)	-9.391*** (-) (5)	0.054 (c) (5)	-3.935*** (c) (7)	-5.343*** (c, t) (1)	0.054 (c, t) (3)	-5.469*** (c) (10)	-7.823*** (-) (22)	0.268 (c) (10)
ΔIntRate(B)	-	-	-	-3.843** (c, t) (9)	-6.623*** (-) (2)	0.058 (c, t) (2)	-	-	-

Variable	Canada			Chile			China		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	1.396 (c, t) (10)	0.045 (c, t) (10)	0.273*** (c, t) (7)	-0.097 (c, t) (11)	-1.240 (c, t) (2)	0.270*** (c, t) (7)	1.764 (c, t) (12)	3.525 (c, t) (1)	0.292*** (c, t) (6)
Real RM	-2.157 (c, t) (12)	-7.832*** (c, t) (2)	0.157** (c, t) (4)	-1.017 (c, t) (3)	-4.009** (c, t) (2)	0.270*** (c, t) (6)	2.271 (c, t) (11)	5.665 (c, t) (65)	0.259*** (c, t) (6)
Real FXR_{cb}	-2.997 (c, t) (12)	-2.604 (c, t) (4)	0.128 (c, t) (6)	-1.920 (c) (9)	-1.912 (c) (3)	0.164** (c, t) (6)	-2.266 (c, t) (11)	2.208 (c,t) (3)	0.270*** (c,t) (7)
ln(Real GDP)	-1.620 (c, t) (9)	-0.222 (c) (5)	0.152** (c, t) (6)	-2.250 (c, t) (12)	-2.504 (c, t) (56)	0.264*** (c, t) (6)	3.476** (c, t) (11)	-14.071*** (c,t) (10)	0.097 (c, t) (16)
ln(REER)	-1.071 (c, t) (2)	-0.711 (c, t) (0)	0.293 (c) (7)	-3.020** (c) (9)	-1.922 (c) (7)	0.184** (c, t) (6)	-3.132 (c, t) (0)	-3.078 (c, t) (6)	0.122 (c) (6)
Inflation	-3.002** (c) (11)	-3.498** (c) (3)	0.138* (c, t) (5)	-2.813 (c, t) (8)	-2.128 (c, t) (3)	0.268*** (c, t) (6)	-3.672*** (c) (10)	-3.894*** (c) (4)	0.087 (c) (5)
IntRate(M)	-3.620** (c, t) (9)	-1.933 (c) (4)	0.155** (c, t) (6)	-4.945*** (c, t) (7)	-5.885*** (c, t) (4)	0.199** (c, t) (6)	-1.006 (c) (12)	-1.457 (c) (3)	0.145* (c, t) (7)
IntRate(B)	-4.362*** (c, t) (5)	-2.874 (c, t) (2)	0.141* (c, t) (6)	-	-	-	-	-	-
First Difference									
ΔReal BM_t/Real BM_{t-1}	-1.424 (c, t) (11)	-12.689*** (c, t) (5)	0.362* (c) (12)	-3.356* (c, t) (10)	-10.647*** (c, t) (6)	0.304 (c) (6)	-2.410 (c) (7)	-7.103*** (c, t) (4)	0.152** (c, t) (4)
ΔReal RM_t/Real RM_{t-1}	-0.555 (c) (11)	-42.074*** (c) (23)	0.085 (c) (13)	-15.845*** (c) (0)	-16.559*** (c) (6)	0.488** (c) (82)	-1.892 (c) (11)	-10.162*** (c, t) (7)	0.316 (c) (11)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-0.893 (c) (11)	-12.358*** (c) (4)	0.162 (c) (3)	-1.776* (-) (8)	-8.449*** (-) (0)	0.266 (c) (1)	-2.180 (c, t) (12)	-5.850*** (c, t) (4)	0.069 (c, t) (5)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-0.914 (c) (11)	-12.676*** (c) (4)	0.149 (c) (3)	-1.936* (-) (8)	-9.229*** (c) (1)	0.172 (c) (2)	-5.096*** (c, t) (0)	-5. 235*** (c, t) (4)	0.095 (c, t) (5)
Δln(Real GDP)	-3.923*** (c) (0)	-4.026*** (c) (2)	0.199 (c) (5)	-1.787 (c) (11)	-19.456*** (c) (77)	0.265 (c) (16)	-2.543 (c) (11)	-67.254*** (c) (12)	0.071 (c) (12)
Δln(REER)	-3.045 (c, t) (12)	-6.510*** (c, t) (4)	0.078 (c, t) (0)	-2.149** (-) (11)	-8.549*** (0) (12)	0.101 (c) (11)	-8.975*** (c, t) (0)	-8.977*** (c, t) (2)	-0.097 (c, t) (4)
Δ(Inflation)	-3.310*** (c) (11)	-7.156*** (-) (4)	0.144 (c) (6)	-5.124*** (c, t) (7)	-7.172*** (-) (4)	0.188 (c) (3)	-2.846*** (-) (12)	-5.333*** (-) (4)	0.127 (c) (4)
ΔIntRate(M)	-4.210*** (c) (12)	-6.786*** (-) (4)	0.083 (c) (4)	-7.460*** (c) (6)	-18. 655*** (-) (8)	0.500** (c) (84)	-3.271*** (-) (11)	-6.439*** (-) (1)	0.131 (c) (4)
ΔIntRate(B)	-4.173*** (c) (9)	-7.411*** (-) (2)	0.068 (c) (1)	-	-	-	-	-	-

Variable	Colombia			Czech Republic			Denmark		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-2.804 (c, t) (12)	-1.171 (c, t) (14)	0.163** (c, t) (7)	-1.907 (c, t) (4)	-1.505 (c, t) (4)	0.204** (c, t) (6)	0.034 (c, t) (9)	-0.842 (c, t) (13)	0.267*** (c, t) (7)
Real RM	-1.146 (c, t) (12)	-1.467 (c, t) (84)	0.266*** (c, t) (6)	-2.426 (c, t) (5)	-2.642 (c, t) (2)	0.128* (c, t) (6)	-0.829 (c, t) (10)	-5.232*** (c, t) (5)	0.124 (c, t) (5)
Real FXR_{cb}	-0.459 (c, t) (0)	-0.578 (c, t) (3)	0.261 (c, t) (7)	-2.533 (c, t) (6)	-2.121 (c, t) (4)	0.084 (c, t) (6)	-2.748 (c, t) (7)	-1.696 (c, t) (3)	0.152** (c, t) (6)
ln(Real GDP)	-1.874 (c, t) (9)	-0.950 (c, t) (4)	0.235*** (c, t) (6)	-2.484 (c, t) (5)	-4.312*** (c, t)	0.166** (c, t) (5)	-1.057 (c, t) (12)	-5.691*** (c, t) (2)	0.223*** (c, t) (6)
ln(REER)	-1.646 (c) (1)	-1.454 (c) (1)	0.149** (c, t) (6)	-3.156 (c, t) (5)	-4.035** (c, t) (2)	0.114 (c, t) (5)	-3.087 (c, t) (1)	-2.067 (c) (3)	0.177** (c, t) (6)
Inflation	-1.288 (c, t) (12)	-2.074 (c, t) (2)	0.212** (c, t) (6)	-1.536 (c) (8)	-2.064 (c) (3)	0.172** (c, t) (5)	-2.530 (c) (11)	-3.467** (c) (0)	0.081 (c) (5)
IntRate(M)	-1.866 (c, t) (12)	-2.649 (c, t) (1)	0.109 (c, t) (6)	-1.074 (c) (1)	-0.905 (c) (4)	0.148** (c, t) (6)	-2.787 (c, t) (12)	-2.610 (c, t) (4)	0.201** (c, t) (6)
IntRate(B)	-	-	-	-	-	-	-2.540 (c, t) (4)	-2.709 (c, t) (2)	0.209** (c, t) (6)
First Difference									
$\Delta \text{Real BM}_t/\text{Real BM}_{t-1}$	-2.151 (c) (12)	-10.519*** (c) (5)	0.090 (c) (15)	-3.515** (c) (10)	-9.972*** (c) (1)	0.104 (c) (7)	-3.120** (c) (8)	-10.473*** (c) (7)	0.379* (c) (10)
$\Delta \text{Real RM}_t/\text{Real RM}_{t-1}$	-2.495 (c, t) (12)	-20.890*** (c) (46)	0.164 (c) (15)	-2.674*** (-) (4)	-12.105*** (c) (2)	0.216 (c) (0)	-5.345*** (c) (8)	-16.129*** (c) (2)	0.047 (c) (8)
$\Delta \text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-4.001*** (c) (2)	-.8.642*** (c) (4)	0.186 (c) (4)	-4.050*** (-) (1)	-6.659*** (c) (3)	0.190 (c) (4)	-2.974** (c) (7)	-7.079*** (c) (0)	0.141 (c) (2)
$\Delta \text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-4.003*** (c) (2)	-8.526*** (c) (4)	0.188 (c) (4)	-4.074*** (-) (1)	-6.753*** (c) (3)	0.224 (c) (4)	-5.227*** (c) (3)	-7.219*** (c) (1)	0.155 (c) (1)
Δln(Real GDP)	-1.564 (c) (8)	-6.881*** (c) (4)	0.258 (c) (4)	-2.919* (c) (10)	-16.005*** (c) (20)	0.102 (c) (12)	-2.551 (c, t) (12)	-27.518*** (c) (10)	0.202 (c) (13)
Δln(REER)	-7.623*** (-) (0)	-7.642*** (-) (1)	0.107 (c) (0)	-3.785*** (c) (10)	-12.120*** (c) (15)	0.093 (c) (14)	-4.948*** (-) (6)	6.784*** (-) (2)	0.038 (c) (2)
Δ(Inflation)	-2.798* (c) (11)	-6.498*** (c) (1)	0.075 (c) (1)	-4.015*** (-) (7)	-5.638*** (-) (2)	0.042 (c) (2)	-5.426*** (-) (7)	-6.749*** (-) (2)	0.050 (c) (2)
ΔIntRate(M)	-3.945*** (c) (8)	-5.569*** (-) (7)	0.047 (c) (1)	-5.833*** (-) (0)	-5.968*** (-) (4)	0.114 (c) (4)	-5.156*** (c) (4)	-8.717*** (-) (2)	0.056 (c) (2)
ΔIntRate(B)	-	-	-	-	-	-	-6.826*** (-) (6)	-17.109*** (-) (10)	0.075 (c) (7)

Variable	Egypt			Hong Kong			Hungary		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-1.738 (c, t) (0)	-1.801 (c, t) (1)	0.233*** (c, t) (7)	-2.367 (c, t) (1)	-1.774 (c, t) (0)	0.193*** (c, t) (5)	-3.612** (c, t) (8)	-2.830 (c, t) (65)	0.285*** (c, t) (6)
Real RM	-1.421 (c, t) (1)	-1.252 (c, t) (3)	0.133* (c, t) (4)	-3.934** (c, t) (4)	-1.551 (c, t) (0)	0.164** (c, t) (5)	-2.947 (c, t) (12)	-2.615* (c) (10)	0.291 (c) (6)
Real FXR_{cb}	-3.083 (c, t) (11)	-1.822 (c, t) (5)	0.128* (c, t) (7)	-1.720 (c, t) (7)	-0.042 (c, t) (2)	0.146** (c, t) (5)	0.408 (c, t) (10)	-1.309 (c, t) (2)	0.237*** (c, t) (6)
ln(Real GDP)	-1.034 (c, t) (4)	-3.052 (c, t) (3)	0.158** (c, t) (3)	-2.451 (c, t) (12)	-5.734*** (c, t) (11)	0.132* (c, t) (5)	2.148 (c, t) (5)	-5.813*** (c, t) (2)	0.241*** (c, t) (4)
ln(REER) (Egypt: ln(NC/USD))	-2.211 (c, t) (6)	-4.089*** (c, t) (4)	0.118* (c, t) (6)	-1.471 (c) (3)	-1.512 (c) (4)	0.319 (c) (7)	-3.159 (c, t) (11)	-2.152 (c, t) (3)	0.077 (c, t) (6)
Inflation	-1.012 (c, t) (12)	-2.628* (c) (6)	0.285** (c, t) (6)	-1.619 (c) (8)	-1.525 (c) (4)	0.734** (c) (6)	-1.971 (c, t) (4)	-2.537 (c, t) (3)	0.180** (c, t) (6)
IntRate(M)	-3.071 (c, t) (1)	-3.402* (c, t) (0)	0.098 (c, t) (6)	-2.027 (c, t) (7)	-2.752 (c, t) (4)	0.097 (c, t) (6)	-1.032 (c, t) (11)	-3.463* (c, t) (4)	0.091 (c, t) (6)
First Difference									
$\Delta\text{Real BM}_t/\text{Real BM}_{t-1}$	-2.980** (c) (5)	-8.590*** (c) (5)	0.155 (c) (4)	-5.614*** (c) (0)	-5.525*** (c) (4)	0.084 (c) (1)	-1.578 (c) (11)	-9.828*** (c) (29)	0.311 (c) (49)
$\Delta\text{Real RM}_t/\text{Real RM}_{t-1}$	-4.216 (c) (0)	-4.214*** (c) (2)	0.209 (c) (2)	-7.114*** (c) (0)	-7.113*** (c) (1)	0.209 (c) (3)	-1.581 (-) (11)	-11.478*** (c) (17)	0.234 (c) (33)
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-4.440*** (c, t) (1)	-7.259*** (c, t) (4)	0.136* (c, t) (5)	-0.131 (c) (10)	-5.677*** (c) (1)	0.134 (c) (2)	-8.277*** (c) (0)	-8.277*** (c) (0)	0.101 (c) (1)
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-3.504** (c) (0)	-3.600** (c) (3)	0.173 (c) (4)	-5.670*** (c) (0)	-5.670*** (c) (0)	0.151 (c) (2)	-8.281*** (-) (0)	-8.264*** (c) (2)	0.164 (c) (0)
Δln(Real GDP)	-2.187** (-) (3)	-6.997*** (-) (31)	0.185 (c) (13)	-2.064 (c) (11)	-9.730*** (-) (15)	0.128 (c) (14)	-1.490 (c, t) (7)	-14.986*** (-) (13)	0.443* (c) (11)
Δln(REER) (Egypt: Δln(NC/USD))	-7.611*** (-) (5)	-8.472*** (c) (5)	0.146* (c, t) (5)	-3.781*** (-) (2)	-5.833*** (-) (0)	0.135* (c, t) (3)	-4.227*** (c) (7)	-7.825*** (c) (11)	0.100 (c) (7)
Δ(Inflation)	-4.435*** (c) (4)	-6.972*** (-) (15)	0.284 (c) (31)	-1.466 (-) (12)	-6.129*** (-) (5)	0.169 (c) (4)	-3.829*** (c) (12)	-5.744*** (-) (1)	0.059 (c) (3)
ΔIntRate(M)	-6.357*** (c) (1)	-5.952*** (c) (10)	0.180 (c) (1)	-2.804*** (-) (6)	-6.318*** (-) (3)	0.137 (c) (4)	-3.916*** (c) (12)	-5.239*** (-) (1)	0.133 (c) (5)

Variable	India			Indonesia			Israel		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-0.939 (c,t) (10)	-0.010 (c,t) (39)	0.289*** (c,t) (7)	-2.025 (c, t) (9)	-2.775 (c,t) (0)	0.220*** (c,t) (6)	-2.510 (c, t) (12)	-2.634 (c, t) (1)	0.147** (c, t) (6)
Real RM	-1.752 (c, t) (9)	-1.063 (c,t) (26)	0.257*** (c,t) (7)	-1.425 (c, t) (7)	-3.940** (c,t) (0)	0.145* (c,t) (5)	-2.916 (c, t) (12)	-1.057 (c, t) (5)	0.080 (c, t) (6)
Real FXR_{cb}	-1.945 (c, t) (12)	-1.918 (c,t) (3)	0.268*** (c,t) (6)	-2.101 (c, t) (6)	-2.371 (c,t) (1)	0.085 (c,t) (6)	-0.784 (c, t) (1)	1.940 (c) (4)	0.120* (c, t) (6)
ln(Real GDP)	-1.226 (c, t) (4)	-6.658*** (c,t) (52)	0152** (c, t) (9)	-3.024 (c, t) (4)	-2.680 (c,t) (20)	0.133* (c, t) (6)	-1.583 (c, t) (11)	-2.640 (c, t) (5)	0.241** (c, t) (6)
ln(REER)	-5.298*** (c, t) (3)	-3.124 (c, t) (2)	0.065 (c, t) (4)	-3.022** (c) (1)	-2.525 (c) (1)	0.174 (c) (5)	-1.560 (c) (0)	-1.513 (c) (2)	0.158* (c, t) (6)
Inflation	-1.677 (c) (8)	-2.363 (c) (1)	0.202** (c, t) (6)	-2.643* (c) (9)	-3.277** (c) (3)	0.110 (c) (5)	-2.198 (c, t) (12)	-1.827 (c) (1)	0.227*** (c, t) (6)
IntRate(M)	-	-	-	-4.034** (c, t) (1)	-2.362 (c) (3)	0.117 (c, t) (6)	-1.645 (c, t) (10)	-3.278* (c, t) (2)	0.154** (c, t) (6)
IntRate(B)	-2.496 (c, t) (10)	-2.004 (c) (3)	0.068 (c, t) (5)	-	-	-	-	-	-
First Difference									
ΔReal BM_t/Real BM_{t-1}	-3.481** (c) (3)	-9.803*** (c) (81)	0.321 (c) (51)	-1.790* (-) (8)	-12.118*** (c, t) (1)	0.129* (c, t) (4)	-4.391*** (c, t) (9)	-8.444*** (c, t) (0)	0.042 (c, t) (0)
ΔReal RM_t/Real RM_{t-1}	-3.648*** (c) (5)	-13.960*** (c) (83)	0.228 (c) (29)	-3.399** (c) (10)	-14.634*** (c) (16)	0.307 (c) (28)	-3.958*** (-) (1)	-7.717*** (-) (4)	0.176 (c) (5)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-1.851 (c) (10)	-5.473*** (c) (5)	0.145 (c) (4)	-4.377*** (c) (10)	-6.635*** (c) (7)	0.043 (c) (3)	-1.651* (-) (7)	-6.874*** (c) (4)	0.132* (c, t) (1)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-1.783 (c) (10)	-5.269*** (c) (4)	0.188 (c) (4)	-3.750*** (c) (5)	-5.276*** (-) (2)	0.059 (c) (0)	-2.877*** (-) (3)	-6.733*** (c) (2)	0.098 (c, t) (2)
Δln(Real GDP)	-1.732 (c) (7)	-17.433*** (c) (11)	0.264 (c) (11)	-3.802*** (c) (5)	-12.081*** (c) (21)	0.139 (c) (27)	-3.570*** (c) (10)	-12.383*** (c) (7)	0.251 (c) (19)
Δln(REER)	-5.849*** (-) (6)	-7.735*** (-) 9	0.100 (c) (3)	-6.143*** (-) (0)	-5.930*** (-) (6)	0.102 (c) (4)	-9.759*** (-) (0)	-9.755*** (c) (1)	0.102 (c) (0)
Δ(Inflation)	-5.948*** (c, t) (7)	-7.285*** (-) (3)	0.079 (c) (2)	-4.147*** (-) (10)	-4.341*** (-) (1)	0.030 (c) (2)	-4.351*** (c, t) (11)	-6.289*** (-) (2)	0.071 (c) (1)
ΔIntRate(M)	-	-	-	-4.547*** (-) (7)	-4.524*** (-) (7)	0.038 (c) (2)	-4.281*** (c) (9)	-8.688*** (-) (6)	0.069 (c) (9)
ΔIntRate(B)	-4.214*** (-) (8)	-5.747*** (-) (1)	0.035 (c) (3)	-	-	-	-	-	-

Variable	Japan			Korea			Malaysia		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-2.477 (c, t) (4)	-2.540 (c, t) (7)	0.207** (c, t) (6)	-2.591 (c, t) (11)	-1.444 (c,t) (5)	0.088 (c,t) (6)	-1.516 (c, t) (11)	-0.961 (c,t) (3)	0.174** (c,t) (6)
Real RM	-3.272* (c, t) (9)	-2.714 (c, t) (12)	0.135* (c, t) (6)	-0.790 (c, t) (11)	-2.513 (c,t) (0)	0.197** (c,t) (6)	-2.822* (c) (2)	-2.343 (c) (4)	0.147** (c,t) (6)
Real FXR_{cb}	-2.096 (c, t) (1)	-2.239 (c, t) (5)	0.256*** (c, t) (7)	-2.324 (c, t) (2)	-2.001 (c,t) (0)	0.218*** (c,t) (6)	-2.207 (c, t) (11)	-1.580 (c,t) (0)	0.233*** (c,t) (6)
ln(Real GDP)	-3.202* (c, t) (6)	-2.755 (c, t) (4)	0.086 (c, t) (6)	-2.363 (c, t) (8)	-6.155*** (c, t) (3)	0.284*** (c, t) (5)	-2.481 (c, t) (12)	-3.022 (c, t) (37)	0.232*** (c, t) (6)
ln(REER)	-2.704 (c, t) (12)	-1.978 (c) (4)	0.163** (c, t) (6)	-2.578 (c) (3)	-1.972 (c) (4)	0.084 (c, t) (6)	-1.609 (c) (2)	-1.554 (c) (1)	0.129 * (c, t) (6)
Inflation	-2.328 (c) (12)	-2.682* (c) (2)	0.174** (c, t) (6)	-2.160 (c) (12)	-3.483** (c, t) (3)	0.161** (c) (5)	-1.924 (c) (9)	-3.296** (c) (1)	0.093 (c, t) (5)
IntRate(M)	-6.228*** (c) (11)	-1.372 (c) (5)	0.229*** (c, t) (7)	-2.712 (c, t) (3)	-2.706 (c, t) (3)	0.114 (c, t) (6)	-3.584** (c, t) (2)	-2.813 (c, t) (4)	0.108 (c, t) (6)
IntRate(B)	-4.380*** (c) (11)	-1.139 (c) (4)	0.280*** (c, t) (6)	-2.393 (c, t) (3)	-3.326* (c, t) (4)	0.138* (c, t) (6)	-3.789** (c, t) (3)	-2.885 (c, t) (4)	0.082 (c, t) (6)
First Difference									
$\Delta\text{Real BM}_t/\text{Real BM}_{t-1}$	-2.731* (c) (7)	-9.369*** (c) (6)	0.356* (c) (7)	-1.177 (c) (11)	-8.499*** (c, t) (3)	0.147** (c, t) (3)	-2.733 (c, t) (9)	-6.968*** (c, t) (3)	0.140* (c, t) (1)
$\Delta\text{Real RM}_t/\text{Real RM}_{t-1}$	-1.684* (c) (7)	-14.716*** (c) (43)	0.129 (c) (19)	-1.924 (c) (12)	-12.358*** (c) (7)	0.100 (c) (10)	-4.207*** (-) (4)	-8.782*** (c, t) (3)	0.069 (c, t) (3)
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-4.266*** (c) (1)	-6.548*** (c) (4)	0.407* (c) (5)	-6.263*** (c) (0)	-6.186*** (c) (3)	0.205 (c) (2)	-6.150** (c) (1)	-5.911*** (-) (6)	0.083 (c) (1)
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-4.393*** (c) (1)	-6.833*** (c) (4)	0.354* (c) (5)	-5.740*** (c) (0)	-5.669*** (c) (3)	0.206 (c) (3)	-6.285*** (c) (1)	-5.914*** (-) (4)	0.105 (c) (0)
Δln(Real GDP)	-4.010*** (c) (7)	-7.871*** (c) (4)	0.174 (c) (4)	-2.580 (c) (7)	-24.967*** (c) (16)	0.330 (c) (13)	-1.218 (-) (11)	-10.065*** (c) (20)	0.363* (c) (19)
Δln(REER)	-3.690*** (-) (11)	-7.878*** (-) (1)	0.059 (c) (3)	-3.956*** (-) (2)	-7.343*** (-) (3)	0.050 (c) (4)	-6.621*** (-) (1)	-6.262*** (-) (5)	0.115 (c) (0)
Δ(Inflation)	-3.517** (-) (11)	-8.475*** (-) (2)	0.073 (c) (1)	-3.887*** (-) (11)	-8.148*** (-) (2)	0.027 (c) (2)	-4.888*** (-) (7)	-6.572*** (-) (4)	0.038 (c) (4)
ΔIntRate(M)	-6.012*** (c, t) (7)	-5.049*** (c) (2)	0.105 (c) (5)	-5.635*** (-) (3)	-6.856*** (-) (11)	0.063 (c) (7)	-5.683*** (-) (0)	-5.622*** (-) (1)	0.111 (c) (4)
ΔIntRate(B)	-3.812** (c, t) (12)	-7.619*** (-) (2)	0.113 (c) (4)	-7.198*** (-) (2)	-7.321*** (-) (13)	0.110 (c) (9)	-4.678*** (-) (3)	-9.186*** (-) (4)	0.056 (c) (4)

Variable	Mexico			New Zealand			Norway		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-1.200 (c, t) (8)	-0.654 (c, t) (20)	0.290*** (c, t) (7)	-1.778 (c, t) (0)	-1.722 (c, t) (2)	0.253*** (c, t) (6)	-0.386 (c, t) (11)	-1.223 (c, t) (2)	0.264*** (c, t) (7)
Real RM	-1.051 (c, t) (12)	-4.647*** (c, t) (31)	0.328*** (c, t) (6)	-1.360 (c, t) (12)	-1.945 (c, t) (3)	0.240*** (c, t) (6)	-5.191** (c, t) (4)	-7.336*** (c, t) (2)	0.041 (c, t) (4)
Real FXR_{cb}	-2.489 (c, t) (9)	-2.554 (c, t) (2)	0.221*** (c, t) (6)	-2.131 (c, t) (1)	-0.863 (c) (1)	0.225*** (c, t) (6)	-2.263 (c, t) (10)	-2.161 (c, t) (2)	0.152** (c, t) (6)
ln(Real GDP)	-2.846 (c, t) (12)	-4.643*** (c, t) (5)	0.092 (c, t) (6)	-2.876 (c, t) (6)	-2.435 (c, t) (4)	0.107 (c, t) (6)	-0.401 (c, t) (12)	-4.594*** (c, t) (3)	0.300*** (c, t) (6)
ln(REER)	-3.090** (c) (3)	-2.719* (c) (5)	0.089 (c, t) (6)	-4134*** (c, t) (12)	-1.983 (c) (4)	0.102 (c, t) (6)	-2.553 (c, t) (4)	-2.439 (c) (1)	0.238*** (c, t) (6)
Inflation	-2.156 (c, t) (8)	-1.975 (c) (4)	0.076 (c, t) (6)	-3.264** (c) (6)	-3.775*** (c) (3)	0.123 (c) (6)	-3.294** (c) (4)	-4.226*** (c) (1)	0.255 (c) (5)
IntRate(M)	-3.852** (c, t) (3)	-2.908 (c, t) (5)	-0.075 (c, t) (6)	-2.387 (c) (2)	-2.438 (c) (2)	0.137* (c, t) (6)	-2.773 (c, t) (7)	-2.005 (c) (3)	0.124* (c, t) (6)
IntRate(B)	-3.859*** (c, t) (6)	-3.449* (c, t) (4)	0.060 (c, t) (6)	-3.453* (c, t) (1)	-2.003 (c) (2)	0.124* (c, t) (6)	-3.116 (c, t) (8)	-2.539 (c, t) (1)	0.167** (c, t) (6)
First Difference									
$\Delta\text{Real BM}_t/\text{Real BM}_{t-1}$	-4.312*** (c) (9)	-11.934*** (c) (19)	0.171 (c) (20)	-11.298*** (c) (0)	-11.295*** (c) (2)	0.089 (c) (2)	-3.374* (c, t) (12)	-11.005*** (c) (1)	0.170 (c) (2)
$\Delta\text{Real RM}_t/\text{Real RM}_{t-1}$	-1.975 (c) (11)	-27.180*** (c) (14)	0.091 (c) (13)	-3.909** (c) (10)	-10.897*** (c) (6)	0.196 (c) (14)	-4.765*** (c, t) (10)	-15.537*** (c) (4)	0.394* (c) (32)
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-5.742*** (c) (3)	-8.031*** (-) (2)	0.037 (c) (1)	-8.169*** (-) (0)	-8.145*** (-) (3)	0.117 (c) (2)	-3.783*** (c) (3)	-11.365*** (-) (0)	0.069 (c) (6)
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-5.440*** (-) (2)	-7.863*** (-) (3)	0.031 (c) (2)	-9.629*** (-) (0)	-9.627*** (-) (1)	0.094 (c) (2)	-3.940*** (-) (3)	-11.177*** (-) (2)	0.085 (c) (7)
Δln(Real GDP)	-3.325** (c) (10)	-17.791*** (c) (13)	0.184 (c) (18)	-2.736* (c) (5)	-8.323*** (c) (3)	0.176 (c) (3)	-1.704 (c, t) (11)	-19.631*** (c) (14)	0.280 (c) (13)
Δln(REER)	-4.212*** (-) (2)	-9.187*** (-) (4)	0.059 (c) (4)	-3.457*** (-) (12)	-6.273*** (-) (0)	0.086 (c) (3)	-6.136*** (-) (3)	-8.090*** (-) (2)	0.126 (c) (1)
Δ(Inflation)	-4.410*** (-) (7)	-4.568*** (-) (2)	0.039 (c) (4)	-3.667*** (-) (11)	-7.293*** (-) (3)	0.143 (c) (3)	-4.735*** (-) (7)	-9.626*** (-) (3)	0.051 (c) (2)
ΔIntRate(M)	-4.974*** (-) (4)	8.720*** (-) (4)	0.051 (c) (4)	-2.920*** (-) (12)	4.446*** (-) (6)	0.082 (c) (1)	-5.780*** (-) (1)	-4.797*** (-) (7)	0.087 (c) (2)
ΔIntRate(B)	-4.330*** (-) (2)	-9.127*** (-) (3)	0.076 (c) (3)	-5.357*** (-) (1)	-4.371*** (-) (5)	0.079 (c) (2)	-5.336*** (c) (4)	-6.065*** (-) (5)	0.067 (c) (2)

Variable	Peru			Philippines			Poland		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
	H_0= I(1)	**H_0= I(1)**	**H_0=I(0)**	**H_0= I(1)**	**H_0= I(1)**	**H_0=I(0)**	**H_0= I(1)**	**H_0= I(1)**	**H_0=I(0)**
Level									
Real BM	-0.572 (c, t) (4)	0.046 (c, t) (1)	0.181** (c, t) (6)	-2.693 (c, t) (12)	-4.999*** (c, t) (4)	0.097 (c, t) (6)	-3.454* (c, t) (8)	-0.551 (c, t) (2)	0.194** (c, t) (6)
Real RM	-0.326 (c, t) (9)	-0.622 (c, t) (35)	0.260*** (c, t) (6)	-2.024 (c, t) (12)	-2.410 (c, t) (23)	0.256*** (c,t) (6)	-2.769 (c, t) (8)	-2.011 (c, t) (1)	0.202** (c, t) (6)
Real FXR_{cb}	-1.551 (c, t) (1)	-1.080 (c, t) (4)	0.221*** (c, t) (6)	-1.675 (c, t) (11)	-0.590 (c, t) (1)	0.186** (c,, t) (6)	-3.008 (c, t) (12)	-2.206 (c, t) (4)	0.152** (c, t) (6)
ln(Real GDP)	-2.372 (c, t) (8)	-5.012*** (c, t) (3)	0.140* (c, t) (6)	-2.264 (c, t) (6)	-9.234*** (c, t) (3)	0.425*** (c, t) (3)	-3.804** (c, t) (4)	-4.241*** (c, t) (56)	0.206** (c, t) (5)
ln(REER)	-1.896 (c) (0)	-1.924 (c) (3)	0.110 (c, t) (5)	-2.225 (c) (11)	-1.508 (c) (0)	0.149** (c, t) (6)	-2.832 (c, t) (1)	-1.668 (c) (5)	0.151** (c, t) (6)
Inflation	-3.169** (c) (8)	-5.985*** (c) (4)	0.265*** (c, t) (5)	-2.552 (c) (8)	-2.423 (c) (0)	0.155** (c, t) (5)	-4.265*** (c) (8)	-3.225** (c) (2)	0.267*** (c, t) (6)
IntRate(M)	-3.078 (c, t) (9)	-2.002 (c) (3)	0.093 (c, t) (6)	-3.480** (c, t) (4)	-3.348* (c, t) (2)	0.967*** (c) (7)	-2.469 (c) (10)	-1.425 (c) (3)	0.198** (c, t) (5)
IntRate(B)	-	-	-	-	-	-	-	-	-
First Difference									
ΔReal BM_t/Real BM_{t-1}	-2.596* (c) (3)	-6.453*** (c) (0)	0.303 (c) (3)	-1.522 (-) (11)	-14.030*** (c) (50)	0.437* (c) (16)	-1.597 (-) (7)	-7.430*** (c) (3)	0.146 (c) (1)
ΔReal RM_t/Real RM_{t-1}	-2.377 (c, t) (10)	-15.163*** (c) (54)	0.223 (c) (17)	-3.223* (c, t) (12)	-17.634*** (c) (34)	0.131 (c) (17)	-3.296** (c) (9)	-14.308*** (c) (1)	0.207 (c) (9)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-4.986*** (c) (0)	-4.971*** (c) (1)	0.134 (c) (4)	-2.523** (-) (10)	-9.226*** (c) (4)	0.119 (c) (4)	-5.183*** (c) (0)	-5.088*** (c) (4)	0.085 (c) (1)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-4.972*** (-) (0)	-4.925*** (-) (1)	0.139 (c) (4)	-8.131*** (c) (0)	-8.082*** (c) (4)	0.075 (c) (2)	-5.515*** (c) (0)	-5.493*** (c) (3)	0.081 (c) (1)
Δln(Real GDP)	-2.544 (c) (7)	-29.572*** (c) (35)	0.192 (c) (15)	-3.978** (c, t) (9)	-37.959*** (c) (13)	0.251 (c) (13)	-2.447 (c) (3)	-17.432*** (c, t) (14)	0.362* (c) (12)
Δln(REER)	-8.540*** (-) (0)	-8.552*** (-) (2)	0.159 (c) (2)	-7.074*** (-) (1)	-6.654*** (-) (6)	0.108 (c) (2)	-3.487** (c) (9)	-6.479*** (-) (7)	0.091 (c) (5)
Δ(Inflation)	-3.155*** (-) (8)	-5.283*** (-) (1)	0.125* (c, t) (4)	-5.421*** (-) (7)	-5.833*** (-) (2)	0.031 (c) (1)	-4.327*** (c, t) (7)	-4.764*** (c) (2)	0.040 (c, t) (4)
ΔIntRate(M)	-4.233*** (-) (0)	-4.078*** (-) (4)	0.136 (c) (3)	-7.590*** (-) (1)	-7.989*** (-) (10)	0.052 (c) (7)	-3.474* (c, t) (10)	-3.219*** (-) (1)	0.132 (c) (3)
ΔIntRate(B)	-	-	-	-	-	-	-	-	-

Variable	Russia			Singapore			South Africa		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-1.996 (c, t) (8)	-1.476 (c, t) (2)	0.237*** (c, t) (6)	-4.148*** (c, t) (12)	-0.132 (c, t) (2)	0.202** (c, t) (6)	-1.311 (c, t) (10)	-1.652 (c, t) (5)	0.269*** (c, t) (7)
Real RM	-1.875 (c, t) (7)	-2.913 (c, t) (6)	0.198** (c, t) (5)	0.036 (c, t) (8)	-1.200 (c, t) (2)	0.210*** (c, t) (6)	-2.398 (c, t) (9)	-2.305 (c, t) (46)	0.292*** (c, t) (6)
Real FXR_{cb}	-1.582 (c, t) (7)	-1.947 (c, t) (4)	0.157** (c, t) (6)	-1.776 (c, t) (12)	-0.756 (c, t) (3)	0.194** (c, t) (7)	-1.428 (c, t) (4)	-1.237 (c, t) (5)	0.250*** (c, t) (7)
ln(Real GDP)	-2.652 (c, t) (8)	-4.823*** (c, t) (14)	0.165** (c, t) (4)	-2.391 (c, t) (12)	-3.080 (c, t) (2)	0.193** (c, t) (6)	-3.090 (c, t) (1)	-2.658 (c, t) (5)	0.269*** (c, t) (6)
ln(REER)	-2.576 (c, t) (1)	-1.428 (c) (1)	0.129* (c, t) (6)	-1.789 (c) (11)	-2.455 (c, t) (4)	0.233 (c) (7)	-1.938 (c) (1)	-1.806 (c) (2)	0.123* (c, t) (6)
Inflation	-2.626 (c, t) (10)	-3.361** (c) (1)	0.114 (c, t) (5)	-0.268 (c, t) (8)	-3.065** (c) (2)	0.243 (c) (5)	-2.121 (c) (12)	-2.422 (c) (1)	0.186** (c, t) (6)
IntRate(M)	-3.425** (c) (10)	-12.364*** (c) (6)	0.207** (c, t) (6)	-3.834** (c, t) (1)	-2.531 (c, t) (0)	0.092 (c, t) (6)	-3.483** (c, t) (7)	-1.522 (c) (2)	0.071 (c, t) (6)
IntRate(B)	-	-	-	-3.175** (c) (5)	-3.344** (c) (0)	0.107 (c, t) (6)	-	-	-
First Difference									
ΔReal BM_t/Real BM_{t-1}	-1.025 (-) (7)	-7.808*** (c) (2)	0.323 (c) (2)	-2.152 (c) (7)	-6.760*** (c) (5)	0.243 (c) (3)	-3.228** (c) (12)	-6.072*** (c) (1)	0.155** (c, t) (4)
ΔReal RM_t/Real RM_{t-1}	-4.398 (c) (6)	-11.551*** (c) (0)	0.232 (c) (16)	-3.436** (c) (7)	-15.931*** (c) (12)	0.173 (c) (39)	-2.672* (c) (7)	-11.454*** (c) (3)	0.220 (c) (24)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-2.753* (c) (6)	5.272*** (c) (1)	0.169 (c) (4)	-8.050*** (c) (0)	-8.136*** (c) (4)	0.276 (c) (4)	-2.061** (c) (7)	-6.725*** (c) (3)	0.235 (c) (4)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-2.849* (c) (6)	-5.371*** (c) (1)	0.156 (c) (4)	-8.425** (c) (0)	-8.454*** (c) (3)	0.163 (c) (3)	-2.002** (-) (7)	-6.654*** (c) (3)	0.052 (c, t) (3)
Δln(Real GDP)	-1.269 (-) (7)	-9.336*** (-) (12)	0.116 (c) (12)	-2.420 (c) (11)	-7.937*** (c) (9)	0.154 (c) (6)	-2.856* (c) (12)	-3.724*** (c) (3)	0.124* (c, t) (5)
Δln(REER)	-5.746*** (-) (0)	-5.571*** (-) (7)	0.059 (c) (2)	-2.075** (-) (10)	-6.445*** (-) (2)	0.352* (c) (4)	-3.258*** (-) (10)	-7.671*** (-) (0)	0.081 (c) (1)
Δ(Inflation)	-4.815*** (-) (9)	-3.450*** (-) (3)	0.063 (c, t) (3)	-6.798*** (c, t) (7)	-4.411*** (-) (2)	0.062 (c) (2)	-3.610*** (-) (11)	-5.490*** (-) (0)	0.078 (c) (0)
ΔIntRate(M)	-5.786*** (-) (9)	-11.096*** (c, t) (0)	0.208** (c, t) (5)	-5.921*** (-) (1)	-5.280*** (-) (11)	0.057 (c) (2)	-3.260*** (-) (10)	-6.529*** (-) (2)	0.043 (c) (2)
ΔIntRate(B)	-	-	-	-4.079*** (-) (5)	-12.044*** (-) (5)	0.089 (c) (11)	-	-	-

Variable	Taiwan			Thailand			Turkey		
	ADF	PP	KPSS	ADF	PP	KPSS	ADF	PP	KPSS
	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)	H_0= I(1)	H_0= I(1)	H_0=I(0)
Level									
Real BM	-2.324 (c, t) (9)	-3.445* (c, t) (4)	0.204** (c, t) (6)	-2.720 (c, t) (12)	-2.139 (c, t) (19)	0.235*** (c, t) (7)	-1.408 (c, t) (0)	-1.196 (c, t) (4)	0.232*** (c, t) (6)
Real RM	0.360 (c) (3)	-1.289 (c) (9)	0.188** (c, t) (6)	-2.531 (c, t) (5)	-.5.579*** (c, t) (0)	0.106 (c, t) (5)	-1.548 (c, t) (7)	-1.801 (c, t) (3)	0.276*** (c, t) (6)
Real FXR_{cb}	-1.779 (c, t) (9)	-1.547 (c, t) (4)	0.268*** (c, t) (7)	1.388 (c, t) (0)	-1.424 (c, t) (1)	0.260*** (c, t) (6)	-2.066 (c, t) (8)	-1.987 (c, t) (1)	0.219*** (c, t) (6)
ln(Real GDP)	-1.826 (c, t) (11)	-5.766*** (c, t) (8)	0.268*** (c, t) (6)	-3.186* (c, t) (11)	-2.658 (c, t) (84)	0.135* (c, t) (6)	-3.100 (c, t) (12)	-9.425*** (c, t) (34)	0.142* (c, t) (28)
ln(REER) (Taiwan: ln(NC/USD))	-1.802 (c) (12)	-1.319 (c) (1)	0.206** (c, t) (6)	-1.507 (c) (12)	-1.878 (c) (5)	0.216*** (c, t) (6)	-4.237*** (c, t) (0)	-4.311*** (c, t) (1)	0.085 (c, t) (4)
Inflation	-1.326 (c) (12)	-3.722** (c, t) (4)	0.194** (c, t) (6)	-2.748 (c, t) (11)	-3.188** (c) (2)	0.086 (c, t) (5)	-1.864 (c, t) (8)	-2.442 (c, t) (2)	0.222*** (c, t) (6)
IntRate(M)	-1.101 (c) (9)	-5.343*** (c, t) (5)	0.124* (c, t) (6)	-2.278 (c, t) (7)	-2.607 (c, t) (3)	0.105 (c, t) (6)	-2.267 (c, t) (5)	-2.696 (c, t) (2)	0.265*** (c, t) (6)
IntRate(B)	-	-	-	-	-	-	-	-	-
First Difference									
$\Delta \text{Real BM}_t / \text{Real BM}_{t-1}$	-2.996 (c, t) (9)	-10.623*** (c) (18)	0.141* (c, t) (22)	-2.123** (-) (11)	-7.839*** (c, t) (7)	0.293*** (c, t) (2)	-2.911** (c) (7)	-9.939*** (c) (8)	0.115 (c) (9)
$\Delta \text{Real RM}_t / \text{Real RM}_{t-1}$	-7.367*** (c) (2)	-11.550*** (c) (14)	0.156 (c) (17)	-3.876*** (c) (4)	-16.441*** (c) (20)	0.185 (c) (17)	-2.982** (c) (7)	-11.876*** (c) (1)	0.339 (c) (5)
$\Delta \text{Real FXR}_{cb,t} / \text{Real BM}_{t-1}$	-3.745*** (c) (2)	-7.361*** (c, t) (3)	0.102 (c, t) (4)	-1.337 (c, t) (12)	-7.893*** (c) (4)	0.345 (c) (5)	-3.111*** (-) (7)	-9.331*** (-) (4)	0.053 (c) (4)
$\Delta \text{Real FXR}_{cb,t} / \text{Real RM}_{t-1}$	-1.117 (-) (8)	-6.131*** (c, t) (3)	0.092 (c, t) (5)	-1.433 (c, t) (12)	-7.968*** (c) (4)	0.318 (c) (5)	-2.911*** (-) (7)	-9.246*** (-) (3)	0.074 (c) (4)
Δln(Real GDP)	-3.514** (c, t) (10)	-23.036*** (c) (15)	0.277 (c) (13)	-1.394 (-) (10)	-8.507*** (c) (20)	0.212 (c) (22)	-2.171 (c) (11)	-12.045*** (-) (13)	0.100 (c) (13)
Δln(REER) (Taiwan: Δln(NC/USD))	-1.944* (-) (11)	-8.535*** (-) (1)	0.088 (c) (0)	-7.892*** (-) (1)	-7.587*** (-) (12)	0.202 (c) (9)	-6.140*** (c) (3)	-10.176*** (-) (5)	0.062 (c) (7)
Δ(Inflation)	-3.660*** (-) (11)	-10.791*** (-) (2)	0.029 (c) (3)	-2.828*** (-) (11)	-5.181*** (-) (6)	0.033 (c) (4)	-4.040*** (c) (7)	-7.956*** (-) (2)	0.130 (c) (2)
ΔIntRate(M)	-3.387** (c) (8)	-13.210*** (c) (2)	0.199 (c) (2)	-5.184*** (-) (4)	-6.040*** (-) (2)	0.060 (c) (3)	-7.125*** (-) (6)	-11.707*** (-) (8)	0.179 (c) (8)
ΔIntRate(B)	-	-	-	-	-	-	-	-	-

Variable	Zivot-Andrews (H_0= I(1))									
	Argentina	**Australia**	**Brazil**	**Canada**	**Chile**	**China**	**Colombia**	**Czech Republic**	**Denmark**	**Egypt**
Level										
Real BM	-4.940 (c, t) (2)	-2.993 (c, t) (1)	-5.440** (c, t) (2)	-3.778 (c, t) (1)	-2.955 (c, t) (2)	-1.911 (c, t) (2)	-3.499 (c, t) (3)	-4.854 (c, t) (2)	-4.868 (c, t) (0)	-2.926 (c, t) (1)
Real RM	-3.970 (c, t) (1)	-4.028 (c, t) (3)	-3.794 (c, t) (1)	-2.921 (c, t) (3)	-4.106 (c, t) (3)	-4.633 (c, t) (1)	-2.843 (c, t) (3)	-4.560 (c, t) (1)	-5.977 (c, t) (3)	-3.671 (c, t) (1)
Real FXR_{cb}	-4.263 (c, t) (2)	-4.690 (c, t) (0)	-2.838 (c, t) (1)	-3.379 (c, t) (1)	-4.022 (c, t) (2)	-3.680 (c, t) (1)	-3.853 (c, t) (0)	-5.299** (c, t) (2)	-3.315 (c, t) (1)	-2.773 (c, t) (2)
ln(Real GDP)	-4.951 (c, t) (1)	-4.237 (c, t) (2)	-7.133** (c, t) (2)	-3.799 (c, t) (1)	-3.100 (c, t) (3)	-15.911*** (c, t) (2)	-4.917 (c, t) (2)	-3.638 (c, t) (1)	-2.279 (c, t) (3)	-5.360** (c, t) (0)
ln(REER) (Egypt: ln(NC/USD))	-11.324*** (c) (1)	-3.267 (c) (2)	-3.985 (c) (0)	-2.753 (c) (2)	-3.543 (c) (2)	-3.514 (c) (0)	-3.695 (c) (1)	-5.208** (c, t) (1)	-4.368 (c) (1)	-5.233** (c, t) (2)
Inflation	-7.329*** (c) (2)	-6.147*** (c) (3)	-4.418 (c) (1)	-5.906*** (c, t) (1)	-3.541 (c, t) (1)	-6.859*** (c) (2)	-5.981*** (c, t) (1)	-5.839*** (c, t) (2)	-5.096** (c) (1)	-4.847 (c, t) (3)
IntRate(M)	-3.733 (c) (2)	-5.386** (c, t) (1)	-5.326** (c, t) (2)	-5.425** (c, t) (2)	-4.016 (c, t) (3)	-4.005 (c, t) (1)	-5.550** (c, t) (1)	-6.010*** (c, t) (1)	-5.635*** (c, t) (0)	-4.570 (c, t) (1)
IntRate(B)	-	-3.777 (c, t) (1)	-	-4.718 (c, t) (1)	-	-	-	-	-5.636*** (c, t) (3)	-
First Difference										
$\Delta\text{Real BM}_t/\text{Real BM}_{t-1}$	-5.514*** (c) (1)	-3.104 (c) (3)	-5.948*** (c) (2)	-4.342 (c) (3)	-4.359 (c) (3)	-4.584 (c) (2)	-2.986 (c) (3)	-6.656*** (c) (2)	-7. 377*** (c) (2)	-7.778*** (c) (0)
$\Delta\text{Real RM}_t/\text{Real RM}_{t-1}$	-13.451*** (c) (0)	-5.855*** (c) (3)	-8.384*** (c) (0)	-5.712*** (c) (3)	-16.250*** (c) (0)	-11.831*** (c) (2)	-4.438 (c) (3)	-14.164*** (c) (0)	-16.019*** (c) (0)	-5.017** (c) (0)
$\Delta\text{Real FXR}_{cb,t}/\text{Real BM}_{t-1}$	-5.428** (c) (1)	-8.974*** (c) (0)	-8.304*** (c) (0)	-4.527 (c) (3)	-6.604*** (c) (2)	-5.679*** (c) (0)	-4.916** (c) (2)	-5.075** (c) (1)	-7.339*** (c) (0)	-5.589*** (c) (1)
$\Delta\text{Real FXR}_{cb,t}/\text{Real RM}_{t-1}$	-4.869** (c) (1)	-9.055*** (c) (0)	-8.308*** (c) (0)	-4.474 (c) (3)	-6.489*** (c) (2)	-5.377** (c) (0)	-4.737** (c) (2)	-5.216** (c) (1)	-7.428*** (c) (0)	-5.414** (c) (0)
Δln(Real GDP)	-9.722*** (c) (2)	-6.719*** (c) (1)	-16.743*** (c) (2)	-4.651 (c) (0)	-3.758 (c) (3)	-133.204*** (c) (2)	-4.954** (c) (1)	-20.302*** (c) (2)	-4.678 (c) (3)	-8.723*** (c) (2)
Δln(REER) (Egypt: Δln(NC/USD))	-6.431*** (c) (1)	-7.404*** (c) (1)	-7.964*** (c) (0)	-7.125*** (c) (1)	-10.363*** (c) (1)	-9.271*** (c) (0)	-7.684*** (c) (1)	-9.668*** (c) (2)	-5.639*** (c) (3)	-5.205** (c) (3)
Δ(Inflation)	-6.580*** (c) (2)	-6.497*** (c) (3)	-5.877*** (c) (1)	-10.239*** (c) (3)	-6.702*** (c) (3)	-5.968*** (c) (0)	-7.464*** (c) (3)	-5.818*** (c) (0)	-7.164*** (c) (3)	-8.145*** (c) (3)
ΔIntRate(M)	-6.618*** (c) (2)	-6.152*** (c) (0)	-7.973*** (c) (1)	-7.332*** (c) (0)	-5.999*** (c) (3)	-7.304*** (c) (0)	-6.553*** (c) (1)	-7.500*** (c) (0)	-9.489*** (c) (0)	-6.512*** (c) (1)
ΔIntRate(B)	-	-7.602*** (c) (0)	-	-6.160*** (c) (3)	-	-	-	-	-6.801*** (c) (3)	-

Variable	Zivot-Andrews (H_0= I(1))									
	Hong Kong	Hungary	India	Indonesia	Israel	Japan	Korea	Malaysia	Mexico	New Zealand
Level										
Real BM	-3.687 (c, t) (1)	-3.885 (c, t) (2)	-2.571 (c, t) (2)	-3.025 (c, t) (1)	-3.640 (c, t) (1)	-4.659 (c, t) (0)	-3.566 (c, t) (2)	-3.241 (c, t) (3)	-4.561 (c, t) (3)	-3.383 (c, t) (0)
Real RM	-4.018 (c, t) (2)	-3.999 (c, t) (2)	-2.879 (c, t) (3)	-5.569** (c, t) (0)	-3.105 (c, t) (3)	-3.717 (c, t) (3)	-4.168 (c, t) (2)	-7.529*** (c, t) (2)	-6.226*** (c, t) (3)	-8.779*** (c, t) (0)
Real FXR_{cb}	-5.284 (c, t) (1)	-3.736 (c, t) (0)	-2.516 (c, t) (2)	-4.754 (c, t) (1)	-3.527 (c, t) (2)	-4.147 (c, t) (3)	-2.806 (c, t) (2)	-2.691 (c, t) (2)	-5.951*** (c, t) (1)	-4.161 (c, t) (1)
ln(Real GDP)	-3.566 (c, t) (3)	-9.894 (c, t) (0)	-8.501*** (c, t) (2)	-9.240*** (c, t) (3)	-4.609 (c, t) (1)	-4.970 (c, t) (3)	-3.170 (c, t) (3)	-5.268** (c, t) (3)	-2.558 (c, t) (3)	-4.221 (c, t) (1)
ln(REER)	-3.707 (c, t) (1)	-3.313 (c, t) (2)	-4.174 (c, t) (2)	-6.786*** (c, t) (1)	-3.493 (c, t) (0)	-3.731 (c) (3)	-4.765 (c) (3)	-6.351*** (c, t) (3)	-4.239 (c) (3)	-3.516 (c) (1)
Inflation	-5.636*** (c, t) (1)	-4.495 (c, t) (1)	-5.385** (c, t) (1)	-7.119*** (c) (1)	-5.421** (c, t) (1)	-3.774 (c, t) (1)	-6.575*** (c, t) (3)	-5.442** (c, t) (1)	-5.454** (c, t) (1)	-5.423** (c) (3)
IntRate(M)	-4.008 (c, t) (2)	-6.507*** (c, t) (2)	-4.464 (c, t) (2)	-5.141** (c, t) (1)	-4.606 (c, t) (2)	-6.907*** (c, t) (2)	-3.796 (c, t) (3)	-5.830*** (c, t) (2)	-4.730 (c, t) (3)	-3.348 (c) (2)
IntRate(B)	-	-	-	-	-	-5.212*** (c, t) (1)	-4.076 (c, t) (3)	-5.410** (c, t) (3)	-5.189** (c, t) (3)	-3.830 (c) (1)
First Difference										
ΔReal BM_t/Real BM_{t-1}	-6.129*** (c) (0)	-9.889*** (c) (2)	-4.584 (c) (3)	-12.916*** (c) (0)	-5.300** (c) (3)	-4.493 (c) (3)	-5.870*** (c) (3)	-8.484*** (c) (0)	-4.257 (c) (3)	-11.650*** (c) (0)
ΔReal RM_t/Real RM_{t-1}	-7.651*** (c) (0)	-8.808*** (c) (2)	-3.963 (c) (3)	-8.194*** (c) (2)	-4.589 (c) (1)	-5.028** (c) (3)	-11.791*** (c) (1)	-6.042*** (c) (1)	-4.164 (c) (3)	-3.515 (c) (3)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-6.103*** (c) (0)	-8.047*** (c) (1)	-5.771*** (c) (0)	-7.225*** (c) (1)	-4.190 (c) (3)	-5.723*** (c) (1)	-7.504*** (c) (1)	-6.711*** (c) (1)	-6.227*** (c) (3)	-8.417*** (c) (0)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-6.719*** (c) (0)	-7.818*** (c) (1)	-5.667*** (c) (0)	-5.839*** (c) (1)	-7.587*** (c) (0)	-5.885*** (c) (1)	-7.311*** (c) (0)	-6.680*** (c) (1)	-6.109*** (c) (3)	-10.087*** (c) (0)
Δln(Real GDP)	-3.401 (c) (3)	-38.304*** (c) (2)	-35.192*** (c) (2)	-3.539 (c) (3)	-4951** (c) (3)	-5.158** (c) (3)	-3.296 (c) (3)	-3.382 (c) (3)	-3.990 (c) (3)	-9.791*** (c) (0)
Δln(REER)	-5.245** (c) (2)	-8.229*** (c) (1)	-7.922*** (c) (0)	-6.940*** (c) (0)	-10.370*** (c) (0)	-4.930** (c) (2)	-4.147 (c) (2)	-7.360*** (c) (1)	-4.649 (c) (2)	-6.615*** (c) (0)
Δ(Inflation)	-6.767*** (c) (3)	-6.144*** (c) (3)	-8.929*** (c) (3)	-7.995*** (c) (3)	-7.016*** (c) (3)	-6.907*** (c) (3)	-7.812*** (c) (3)	-9.142*** (c) (3)	-6.036*** (c) (3)	-6.429*** (c) (3)
ΔIntRate(M)	-9.010*** (c) (0)	-4.672 (c) (2)	-5.957*** (c) (0)	-7.127*** (c) (2)	-6.286*** (c) (3)	-3.537 (c) (1)	-7.409*** (c) (3)	-6.524*** (c) (0)	-5.225** (c) (3)	-6.312*** (c) (1)
ΔIntRate(B)	-	-	-	-	-	-7.844*** (c) (0)	-8.068*** (c) (2)	-5.253** (c) (3)	-5.122** (c) (3)	-5.870*** (c) (1)

Variable	Zivot-Andrews (H_0= I(1))									
	Norway	**Peru**	**Philippines**	**Poland**	**Russia**	**South Africa**	**Singapore**	**Taiwan**	**Thailand**	**Turkey**
Level										
Real BM	-2.914 (c, t) (2)	-3.337 (c, t) (1)	-3.586 (c, t) (3)	-3.510 (c, t) (0)	-3.348 (c, t) (2)	-2.963 (c, t) (3)	-4.165 (c, t) (1)	-3.391 (c, t) (2)	-3.047 (c, t) (2)	-4.402 (c, t) (0)
Real RM	-4.868 (c, t) (2)	-4.338 (c, t) (1)	-5.841*** (c, t)(3)	-7.329*** (c, t) (3)	-3.923 (c, t) (2)	-1.978 (c, t) (3)	-3.200 (c, t) (2)	-2.479 (c, t) (3)	-4.427 (c, t) (3)	-3.400 (c, t) (1)
Real FXR_{cb}	-2.666 (c, t) (1)	-3.804 (c, t) (1)	-4.613 (c, t) (1)	-3.293 (c, t) (3)	-3.073 (c, t) (1)	-3.490 (c, t) (2)	-3.301 (c, t) (0)	-3.782 (c, t) (3)	-3.183 (c, t) (0)	-3.206 (c, t) (0)
ln(Real GDP)	-1.901 (c, t) (3)	-3.686 (c, t) (3)	-2.519 (c, t) (3)	-6.045*** (c, t) (1)	-3.067 (c, t) (2)	-3.273 (c, t) (1)	-3.756 (c, t) (3)	-2.512 (c, t) (3)	-4.198 (c, t) (2)	-2.807 (c, t) (3)
ln(REER) (Taiwan: ln(NC/USD))	-4.829 (c, t) (1)	-3.420 (c, t) (0)	-3.136 (c) (2)	-5.193** (c, t) (3)	-7.108*** (c) (1)	-3.815 (c) (0)	-2.450 (c) (1)	-5.146** (c, t) (0)	-6.095*** (c, t) (2)	-6.683*** (c, t) (0)
Inflation	-5.776*** (c) (3)	-4.902 (c, t) (1)	-5.672*** (c, t) (1)	-22.402*** (c, t) (2)	-5.121** (c, t) (2)	-4.771 (c, t) (1)	-6.875*** (c, t) (1)	-7.163*** (c, t) (3)	-6.291*** (c, t) (1)	-3.633 (c, t) (0)
IntRate(M)	-3.758 (c, t) (2)	-6.081*** (c) (0)	-5.323** (c, t) (1)	-6.068*** (c, t) (1)	-9.901*** (c, t) (2)	-3.470 (c, t) (1)	-5.347** (c, t) (1)	-4.425 (c, t) (1)	-5.551*** (c, t) (2)	-5.166 (c, t) (0)
IntRate(B)	-4.385 (c, t) (2)	-	-	-	-	-	-3.219 (c, t) (2)	-	-	-
First Difference										
ΔReal BM_t/Real BM_{t-1}	-11.357*** (c) (0)	-8.061*** (c) (0)	-5.370** (c) (3)	-9.155*** (c) (0)	-4.685 (c) (1)	-7.181*** (c) (0)	-3.930 (c) (3)	-4.487 (c) (3)	-4. 836** (c) (3)	-8.994*** (c) (1)
ΔReal RM_t/Real RM_{t-1}	-15.252*** (c) (0)	-10.355*** (c) (2)	-4.019 (c) (3)	-7.520*** (c) (2)	-5.831*** (c) (2)	-4.509 (c) (3)	-5.756*** (c) (3)	-8.909*** (c) (2)	-6.493*** (c) (3)	-12.394*** (c) (0)
ΔReal $FXR_{cb,t}$/Real BM_{t-1}	-11.761*** (c) (0)	-5.735*** (c) (0)	-8.333*** (c) (1)	-5.650*** (c) (0)	-6.818*** (c) (0)	-7.046*** (c) (0)	-9.523*** (c) (0)	-4.859** (c) (2)	-4.280 (c) (3)	-7.847*** (c) (1)
ΔReal $FXR_{cb,t}$/Real RM_{t-1}	-11.398*** (c) (0)	-6.245*** (c) (0)	-7.610*** (c) (1)	-6.488*** (c) (0)	-6.855*** (c) (0)	-7.022*** (c) (0)	-9.592*** (c) (3)	-4.500** (c) (2)	-4.213 (c) (3)	-8.218*** (c) (1)
Δln(Real GDP)	-22.423*** (c) (2)	-4.961** (c) (3)	-6.265*** (c) (3)	-22.181*** (c) (2)	-13.651*** (c) (2)	-5.179** (c) (0)	-3.841 (c) (3)	-3.168 (c) (3)	-3.215 (c) (3)	-4.747 (c) (3)
Δln(REER) (Taiwan: Δln(NC/USD))	-6.689*** (c) (3)	-9.156*** (c) (0)	-8.107*** (c) (1)	-9.009*** (c) (3)	-5.987*** (c) (0)	-8.536*** (c) (0)	-7.622*** (c) (0)	-6.345*** (c) (3)	-8.436*** (c) (1)	-7.859*** (c) (1)
Δ(Inflation)	-9.100*** (c) (3)	-5.218** (c) (0)	-9.126*** (c) (3)	-33.909*** (c) (3)	-8.412*** (c) (1)	-8.925*** (c) (3)	-8.358*** (c) (3)	-6.456*** (c) (3)	-8.338*** (c) (3)	-8.255*** (c) (3)
ΔIntRate(M)	-6.022*** (c) (1)	-7.978*** (c) (2)	-7.666*** (c) (1)	-4.837** (c) (2)	-4.638 (c) (2)	-7.139*** (c) (0)	-6.516*** (c) (2)	-14.458*** (c) (0)	-6.218*** (c) (0)	-8.780*** (c) (1)
ΔIntRate(B)	-7.158*** (c) (1)	-	-	-	-	-	-4.921** (c) (3)	-	-	-

Section C: Country Data Notes

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Argentina							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF)/ Banco Central de la Repùblica Argentina (BCRA)	Currency in circulation and current account deposits. Excludes foreign currency denominated deposits. IMF IFS (19MA.ZF)/BCRA.	IMF IFS (.1D.DZF)	1993 prices. IMF IFS (99B.PYF).	Deposit rate: Weighted average rate from financial institutions in Buenos Aires and surrounding areas on 30- to 59-day time deposits in the national currency. The rate is weighted by deposit amounts. IMF IFS (60L..ZF).	CPI-Based (2005=100). Data points are monthly averages. Bank for International Settlements (BIS).	IMF IFS (64...ZF)
Series Length	1992q1-2010q2			1993q1-2010q2	1991q1-2010q2	1994q3-2010q2	1992q1-2010q2/ 1993q1-2010q2
Notes	An opportunity cost variable is excluded because no data on Government bill/bond rates are presented in the IFS.						
Australia							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF)/ Reserve Bank of Australia (RBA).	Money base (national definition). Currency in circulation, deposits of banks with RBA and other RBA liabilities to the non-bank private sector. IMF IFS (19MA.ZF)/RBA.	IMF IFS (.1D.DZF)	2001-02 prices. IMF IFS (99B.RYF).	Deposit rate: Average rate offered by major banks on 3-month fixed deposits of AUD 10,000. IMF IFS (60L..ZF). Treasury bond yield: 2-year non-rebate bonds (3-year from June 1992). IMF IFS (61A..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Brazil							
Definition and Source	M3 adjusted to exclude operations committed with Federal Securities. Includes Federal Government and non-resident deposits. Banco Central do Brasil (BCB).	Currency in circulation, banking reserves, interest-bearing and non-interest-bearing required reserves. BCB (Via email correspondence).	IMF IFS (.1D.DZF) Includes domestic government securities payable in foreign currency.	Nominal GDP deflated by the GDP deflator. IMF IFS (99B..ZF and 99BIPZF)/ Brazil Institute of Geography and Statistics (IBGE) for 2010q2 nominal GDP value.	Deposit rate: Average rate offered by banks on certificates of deposit of 30 days or longer. IMF IFS (60L..ZF).	CPI-Based (2005=100). Data points are monthly averages. BIS	IMF IFS (64...ZF)
Series Length	1995q3-2010q2			1995q1-2010q2	1995q3-2010q2	1994q1-2010q2	1995q3-2010q2/ 1996q3-2010q2
Notes	An opportunity cost variable is excluded because of missing values in the IFS Treasury bill series (1998q3 and 1998q4).						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Canada							
Definition and Source	M3 Gross (national definition). IMF IFS (59MCA.ZF).	Currency in circulation and liabilities to other depository corporations. IMF IFS (14...ZF and 14...ZK).	IMF IFS (.1D.DZF)	2002 prices. IMF IFS (99B.RWF).	Deposit rate: Rate offered by chartered banks on 90-day deposits in national currency.IMF IFS (60L..ZF). Government bond yield: Average yield to maturity of 3-5 years. IMF IFS (61A..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Chile							
Definition and Source	M3 adjusted to exclude central bank instruments and treasury bonds. Data points are monthly averages. Banco Central de Chile (BCC)	Currency in circulation and monetary reserves of other depository corporations. BCC.	IMF IFS (.1D.DZF)	Linked Series. Base =2003. BCC.	Deposit rate: Weighted average rate paid by banks on 30- to 89-day deposits in national currency. The rate is converted to percent per annum by compounding monthly rates of interest. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	Base=2008. BCC.
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded as no data on Government bill/bond rates are presented in the IFS.						
China							
Definition and Source	M2 (national definition). IMF IFS (59MB.ZF)/People's Bank of China (PBOC).	Currency issued and deposits of financial corporations. IMF IFS (14...ZF)/PBOC.	IMF IFS (.1D.DZF). Prior to 1992, includes foreign exchange holdings of the Bank of China. Starting in that year, comprises foreign exchange holdings of the PBOC only.	Abeysinghe and Gulasekaran (2004) for data up to 1999q4. Level series extended forwards based on growth rates sourced from Datastream.	Deposit rate: Institutional and individual deposits of one year maturity. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	Datastream.
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded as no data on Government bill/bond rates are presented in the IFS.						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Colombia							
Definition and Source	M3 (national definition). Includes deposits of the Federal Government, mortgage certificates issued by the Central Mortgage Bank, and bonds issued by other depository corporations. IMF IFS (59MC.ZF).	Currency in circulation and monetary reserves. IMF IFS (14...ZF and 14...ZK)/ BANREP.	IMF IFS (.1D.DZF)	Seasonally adjusted nominal GDP, deflated by the GDP deflator (2005=100). IMF IFS (99B.CZF and 99BIPZF).	Deposit rate: Weighted average rate paid by depository corporations on 90-day certificates of deposit (fixed-term deposits). IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2			1994q1-2010q2	1989q1-2010q2		1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded as no data on Government bill/bond rates are presented in the IFS.						
Czech Republic							
Definition and Source	M3 (national definition) – 2002 to 2010. Czech National Bank (CNB). Prior to 2002, IMF IFS: Broad Money Liabilities (35L.ZK) and Money + Quasi-Money (35L.ZF). Break in series in 2002.	Currency, required and excess reserves. CNB.	IMF IFS (.1D.DZF)	CNB	Deposit rate: Average rate, weighted by stocks, offered by commercial banks on the outstanding koruna denominated deposits of non-financial sectors. Prior to January 2001, it is the average rate on all deposits weighted by stocks.IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1993q1-2010q2	1992q4-2010q2	1993q1-2010q2	1996q1-2010q2	1993q1-2010q2	1990q1-2010q2	1993q1-2010q2/ 1994q1-2010q2
Notes	An opportunity cost variable is excluded due to missing values in the Treasury bill rate series and a relatively short Government bond yield series (beginning only in 2000) in IFS.						
Denmark							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF).	2000q3-2010q2: IMF IFS (14...ZK). 1989q1-2010q2: Currency and net deposits from other institutions and individuals. Danmarks Nationalbank (DN).	IMF IFS (.1D.DZF)	Nominal GDP deflated by GDP deflator (2005=100). IMF IFS (99B..ZF and 99BIPZF).	Deposit rate: 3-month money market rate, DN. Government bond yield: Secondary market yields of government bonds with a 10-year maturity. IMF IFS (61...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Egypt							
Definition and Source	IMF IFS. 2001q4 onwards: Broad Money Liabilities, adjusted to exclude securities other than shares (35L.ZK - 36A.ZK). Before 2001q4, Money + Quasi Money ((35L.ZF).	Currency in circulation, liabilities to other depository corporations and liabilities to other sectors. IMF IFS (14...ZK).	IMF IFS (.1D.DZF)	GDP data on a quarterly basis are only available from 2002q1 onwards (national agencies as well as IMF IFS). As such real GDP is excluded from the set of explanatory variables to avoid problems associated with insufficient data.	Deposit rate: Rate offered by commercial banks and finance companies on 180-day time deposits in national currency.IMF IFS (60L..ZF).	There is no readily available data series for the REER (or NEER) from IMF IFS or BIS. As such, the average value of the NC/USD exchange rate (..AF.ZF) is used as an explanatory variable in the regression analysis.	IMF IFS (64...ZF)
Series Length	1989q1-2010q2	2001q1-2010q4	1989q1-2010q2	2002q1-2010q2	1989q1-2010q2		1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded since the Treasury bill rate series is only available from 1997q1.						
Hong Kong							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF)/Hong Kong Monetary Authority (HKMA).	Currency (certificates of indebtedness and HKMA -issued notes and coins), clearing accounts of banking institutions with the HKMA (national and foreign currencies). Adjusted to exclude outstanding exchange fund bills and notes issued by the HKMA. HKMA.	IMF IFS (.1D.DZF) Includes foreign exchange reserves of the Hong Kong Government's Land Fund.	Chain volume GDP (Reference year=2008). IMF IFS (99B.PSF).	Deposit rate: Average interest rate on one month deposits of 10 major banks. Prior to January 1995, the data refers to the maximum rates paid by licensed banks under the interest rate rules of the Association of Banks. IMF IFS (60L..ZF).	Based on unit labour cost. IMF IFS (..RELZF)	IMF IFS (64...ZF)
Series Length	1996q4-2010q2	1998q3-2010q2	1996q4-2010q2	1989q1-2010q2	1994q1-2010q2	1989q1-2010q2	1989q1-2010q2/ 1990q1-2010q2
Notes	The annualized yields on Exchange Fund bills of 91-day maturity (reported in the IMF IFS in the Treasury Bill Rate line) is not included in the estimation as the opportunity cost variable since the bulk of these are held by banks (88% at end June 2010).						
Hungary							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF).	Currency in circulation, current accounts of monetary financial institutions (MFIs), and overnight deposits of MFIs. Magyar Nemzeti Bank (MNB).	IMF IFS (.1D.DZF) Includes swapped gold.	2000 prices. IMF IFS (99B.PVF).	Deposit rate: For deposits of up to one year. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1990q4-2010q2		1989q1-2010q2	1995q1-2010q2	1989q1-2010q2		1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded since the Treasury bill rate series is strongly correlated with the deposit rate both in levels and first differences.						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
India							
Definition and Source	Money + Quasi Money. IMF IFS (35L.ZF).	Currency in circulation, deposits of the deposit money banks, and deposits of other residents. IMF IFS (14...ZF).	IMF IFS (.1D.DZF)	GDP at1999-2000 prices. Data points over 2009q4-2010q2 derived based on growth rates for GDP at 2004-05 prices. Reserve Bank of India (RBI).	Treasury bill yield: 91-day auction yield. Datastream.	CPI-Based (2005=100). Data points are monthly averages. BIS.	IMF IFS (64...ZF)
Series Length	1989q1-2010q2			1996q1-2010q2	1993q1-2010q2	1994q1-2010q2	1989q1-2010q2/ 1990q1-2010q2
Notes	There is a lack of data on deposit rates and the call money rate series has missing values in the IFS.						
Indonesia							
Definition and Source	M2 (national definition). Bank Indonesia.	Currency in circulation, commercial bank demand deposits, private sector demand deposits, and Bank Indonesia certificates (used as secondary reserves). Bank Indonesia.	IMF IFS (.1D.DZF)	2000q1-2010q2. GDP at 2000 prices. IMF IFS (99B.PVF). Level series backdated based on growth rates of GDP at 1993 prices from Abeysinghe and Gulasekaran (2004).	Deposit rate: Weighted average rate on 3-month national currency time deposit. IMF IFS (60L..ZF).	CPI-Based (2005=100). Data points are monthly averages. BIS.	IMF IFS (64...ZF)
Series Length	1989q1-2010q2	1993q4-2010q2	1989q1-2010q2			1994q1-2010q2	1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded because of the lack of data for the government bill/bond rate in the IFS.						
Israel							
Definition and Source	M3 (national definition). Includes deposits of non-residents. Data points are monthly averages. Bank of Israel.	Currency in circulation, foreign currency and local currency deposits of banks. The deposits include required reserves and local currency interest earning deposits. Bank of Israel.	IMF IFS (.1D.DZF). From January 1997, includes accrued interest on securities.	Nominal GDP deflated by GDP deflator (2005=100). IMF IFS (99B..ZF and 99BIPZF).	Deposit rate: Average rate offered by commercial banks on all short-term deposits up to one year. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded since the Treasury bill rate series is strongly correlated with the deposit rate both in levels and first differences.						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Japan							
Definition and Source	M3 (national definition). Includes non-resident deposits in national currency. IMF IFS (59MC.ZF).	Currency in circulation and current account deposits with the Bank of Japan (BOJ). BOJ.	IMF IFS (.1D.DZF).	Chain volume GDP (Reference year=1995). IMF IFS (99B.RXF).	Deposit rate: Average interest rate on unregulated 3-month time deposits (3 million to <10 million yen). IMF IFS (60L..ZF). Government bond yield: Average yield on newly issued bonds with 10-year maturity. IMF IFS (61...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Korea							
Definition and Source	M2 (national definition). IMF IFS (59MB.ZF).	Currency in circulation, reserve deposits of banking institutions and demand deposits of the private sector in national currency with the Bank of Korea (BOK)/IMF IFS (14.ZF).	IMF IFS (.1D.DZF).	Nominal GDP deflated by GDP deflator (2005=100). IMF IFS (99B..ZF and 99BIPZF).	Deposit rate: BOK maximum guideline rate on time deposits of 1-year or more. From July 1996, weighted average rate for deposits of >= 1-year, but < 2-years. IMF IFS (60L..ZF). Government bond yield: Average yield on National Housing Bonds. IMF IFS (61...ZF).	Based on unit labour cost. IMF IFS (..RELZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Malaysia							
Definition and Source	M3 (national definition). Includes non-resident deposits. IMF IFS (59MC.ZF).	Currency in circulation, required and excess reserves, and deposits of the private sector with Bank Negara Malaysia (BNM). BNM.	IMF IFS (.1D.DZF).	GDP at 1987 prices. IMF IFS (99B..PYF) – 1991q1-2003q4. Level series extended based on GDP at 2000 prices growth rates (IMF IFS (99B..PXF)). Past values based on Abeysinghe and Gulasekaran (2004).	Deposit rate: Average rate on local currency 3-month time deposits at commercial banks. IMF IFS (60L..ZF). Government bond yield: Average discount rate on 3-month treasury bills.IMF IFS (60C...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Mexico							
Definition and Source	M2 (national definition). Includes the private sector's holdings of public securities. IMF IFS (59MB.ZF).	Currency in circulation and demand deposits of commercial and development banks at the Bank of Mexico. IMF IFS (14.ZK and 19MA.ZF).	IMF IFS (.1D.DZF). Includes interest accrued on deposits, securities, and other obligations payable, loans granted to central banks, SDR holdings, and the difference in favour of the central bank between the value of foreign exchange receivable and payable on futures in foreign currencies.	GDP at 2003 prices. IMF IFS (99B.RVF) – 2003q1-2010q2. Level series extended backwards based on growth rates of GDP at 1993 prices (IMF IFS (99B.RWF)).	Deposit rate: Weighted average rate paid to individuals on 60-day time deposits. IMF IFS (60L..ZF). Government bond yield: Average yield on 28-day Treasury bills.IMF IFS (60C...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
New Zealand							
Definition and Source	M3R. Does not include NZ dollar deposits from non-residents. Reserve Bank of New Zealand (RBNZ).	Currency in circulation and other liabilities to banking institutions. IMF IFS (14.ZF).	IMF IFS (.1D.DZF).	GDP volume at 1995-96 prices. IMF IFS (99B.RXF).	Deposit rate: Weighted average rate offered by New Zealand's six largest banks on 6-month deposits of $NZ 10,000 or more.IMF IFS (60L..ZF). Government bond yield: Tender rate on 3-month Treasury bills (61...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	There is strong correlation between the deposit rate and the Treasury bill rate both in levels and first differences.						
Norway							
Definition and Source	M2 (national definition). Statistics Norway and IMF IFS (59MB. ZF).	Currency in circulation; banks' current accounts and time deposits, and money holding sectors' deposits with Norges Bank. Statistics Norway and IMF IFS (14... ZF).	IMF IFS (.1D.DZF).	GDP 2007 prices. IMF IFS (99B.PTF).	Deposit rate: Weighted average rate on bank deposits. Statistics Norway. Government bond yield: Yield to maturity on 5-year Government bonds. IMF IFS (61...ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Peru							
Definition and Source	Total liquidity in the banking system. Central Reserve Bank of Peru (BCRP).	Currency in circulation, demand deposits in national currency of deposit money banks and other banking institutions at the BCRP. IMF IFS (19MA.ZF).	IMF IFS (.1D.DZF).	GDP at 1994 prices. IMF IFS (99B.PYF).	Deposit rate: Weighted average rate on all deposits in national currency. The rate is weighted by the individual banks' participation in total deposits. IMF IFS (60L..ZF).	CPI-Based (2005=100). Data points are monthly averages. BIS.	IMF IFS (64...ZF)
Series Length	1993q1-2010q2					1994q1-2010q2	1993q1-2010q2/ 1994q1-2010q2
Notes	An opportunity cost variable is excluded as no data on Government bill/bond rates are presented in the IFS.						
Philippines							
Definition and Source	M4 (national definition). Bangko Sentral ng Pilipinas (BSP) and IMF IFS (59MD.ZF).	Currency in circulation, required and excess reserves. BSP and IMF IFS (19MB.ZF and 14...ZK).	IMF IFS (.1D.DZF).	GDP at 1985 prices. 1989-2003: Abeysinghe and Gulasekaran (2004). 2003-2010: National Statistics Coordination Board.	Deposit rate: Weighted average rate offered by universal and commercial banks on 61-to 90-day time deposits in national currency. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded because of missing values in the time series for the Treasury bill rate in the IFS.						
Poland							
Definition and Source	M3 (national definition). IMF IFS (59MC.ZF).	Currency in circulation and current account balances of other MFIs with the National Bank of Poland (NBP) in national currency. IMF IFS (14...ZF and 14...ZK).	IMF IFS (.1D.DZF).	Chain volume GDP (Reference year=1995). Datastream.	Deposit rate: 3-month average weighted deposit rate. NBP.	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1996q4-2010q2	1993q1-2010q2		1996q1-2010q2	1996q4-2010q2	1993q1-2010q2	1992q1-2010q2/ 1993q1-2010q2
Notes	An opportunity cost variable is excluded since the Treasury bill rate series is strongly correlated with the deposit rate both in levels and first differences, and given that the regression sample size is reduced on account of the relatively short series for broad money and GDP.						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Russia							
Definition and Source	Broad Money Liabilities (national definition). Includes private sector deposits with the Central Bank of the Russian Federation (CBR). CBR/ IMF IFS (59MCA.ZF).	Currency in circulation, other depository corporations (ODCs)' required reserves and correspondent accounts in national currency with the CBR, CBR bonds held by ODCs, and the CBR's obligation to buy back securities. CBR/ IMF IFS (19MAA.ZF and 14...ZK).	IMF IFS (.1D.DZF).	GDP at 2003 prices. IMF IFS (99B.PXF).	Deposit rate: Rate for 1-month time deposits of > Rub 300,000 up to end 1996. From January 1997, weighted average rate offered by ODCs on deposits of households in national currency with maturity of up to 1-year. The rate is weighted by deposit amounts. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1995q2-2010q2		1995q1-2010q2		1994q3-2010q2	1994q1-2010q2	1994q1-2010q2/ 1995q1-2010q2
Notes	An opportunity cost variable is excluded as the Treasury bill series has missing values while the Government bond yield series only begins from 2005q2 in the IFS.						
Singapore							
Definition and Source	M3 (national definition). Monetary Authority of Singapore (MAS) and IMF IFS (59MC.ZF).	Currency in circulation, deposits of deposit money banks and deposits of other residents. IMF IFS (14.ZF).	IMF IFS (.1D.DZF). Includes gold and government foreign exchange holdings. From August 2000, excludes gold holdings.	GDP at 2005 prices. Datastream.	Deposit rate: Average rate offered by the 10 leading commercial banks on 3-month time deposits .IMF IFS (60L..ZF). Government bond yield: Mode/average bid on 3-month Treasury bills (6OC..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
South Africa							
Definition and Source	M3 (national definition). Currency in circulation and all the deposits of the private sector with the monetary sector. IMF IFS (59MC.ZF).	Currency in circulation and deposits of banks and mutual banks with the South African Reserve Bank (SARB). SARB.	IMF IFS (.1D.DZF). Includes small foreign exchange holdings by the Government.	GDP at 2005 prices. IMF IFS (99B.RYF).	Deposit rate: Quoted/weighted rate, wholesale 88-91 day deposits. From January 2008, weighted average rate, wholesale 32-91 day deposits. IMF IFS (60L..ZF).	Based on relative CPI. IMF IFS (..RECZF)	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded since the Treasury bill rate and the Government bond yield are strongly correlated with the deposit rate.						

Variable/ Country	Broad Money	Base Money	Foreign Exchange Reserves	Real GDP	Interest Rates	REER	CPI/Inflation
Taiwan							
Definition and Source	M2 (national definition). Central Bank of the Republic of Taiwan (CBC).	Currency in circulation and reserves of deposit money banks and Chunghwa Post Co. CBC.	CBC.	GDP at 2006 prices. CBC.	Deposit rate: End-of-period 1-year deposit rate of banks. CBC.	There is no data available on the NEER and REER. The bilateral exchange rate between the New Taiwan Dollar and the US dollar is used in the regression analysis.	CBC.
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded because of the lack of a long series for the government bond/bill rate. The 10-year Government bond rate series is only available from 1995.						
Thailand							
Definition and Source	Broad Money (national definition). Money holders are the domestic sectors. Excludes Federal Government and non-residents. 1997-2010: Bank of Thailand (BOT)/IMF IFS (59MEA.ZF). 1989-1996: BOT.	Currency in circulation, deposits of other depository corporations, and deposits of the private sector included in broad money. BOT.	IMF IFS (.1D.DZF).	GDP at 1988 prices. 1993-2010: IMF IFS (99B.PYF). 1989-1992: Abeysinghe and Gulasekaran (2004).	Deposit rate: End-of-period maximum rate offered by commercial banks on 6-month time deposits. IMF IFS (60L..ZF).	Based on relative CPI. BOT.	IMF IFS (64...ZF)
Series Length	1989q1-2010q2						1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded because of the lack of a long series for the Treasury bill rate (the series begins 2001q1). The long-term government bond yield is unchanged over the period 1990q3-1998q3 in the IFS.						
Turkey							
Definition and Source	M2YR up to November 2005, M3 from December 2005 onwards (national definitions). Central Bank of the Republic of Turkey (TCMB).	Currency in circulation, required and excess reserves of commercial banks in national currency and demand deposits in national currency of other sectors at the TCMB. TCMB.	IMF IFS (.1D.DZF).	GDP at 1998 prices. IMF IFS (99B.PYF). Extended backwards for the period 1989-1997 based on growth rates of GDP at 1987 prices. IMF IFS (99B.PZF).	Deposit rate: Rate on 3-month time deposits denominated in national currency. IMF IFS (60L..ZF).	CPI-Based (2005=100). Data points are monthly averages. BIS.	IMF IFS (64...ZF)
Series Length	1989q1-2010q2					1994q1-2010q2	1989q1-2010q2/ 1990q1-2010q2
Notes	An opportunity cost variable is excluded since there are missing values in the Treasury bill rate series in the IFS.						

<u>APPENDIX 3</u>:
MONETARY POLICY AND EXCHANGE RATE FRAMEWORKS (1990-2010)

Country	Monetary Policy and Exchange Rate Framework	
Argentina	1991-January 2002 2002-2005 2005-2010	Currency board. IMF supported monetary programme. Monetary programme: communication of inflation target and projected broad money growth. 2002: Freely falling exchange rate; 02/2003-01/2007: *De facto* crawling band narrower than/equal to +/-5%; 02/2007-06/2009: *De facto* crawling band narrower than/equal to +/-2%; 07/2009-2010: *De facto* crawling peg.
Australia	1990-1993 1993-2010	Discretionary monetary policy framework. Inflation-targeting framework adopted in 1993. The policy rate is the cash rate (the rate charged on overnight loans between financial intermediaries). 1990-2010: Freely floating.
Brazil	1990-1994 1994-1998 January 1999-2010	Fixed peg (freely falling). Crawling peg (Pre-announced crawling band that is narrower than or equal to +/-2%). 02-08/1999: Freely falling. Inflation-targeting. Policy rate/operational target: Selic rate, which is the interest rate on overnight interbank loans collateralised by federal debt instruments. 09/1999-2010: Managed floating.
Canada	1990-2010	Inflation-targeting framework formally adopted in 1991. The policy rate is the overnight rate. Operationally, short-term interest rates and price stability were also the instrument and ultimate objective respectively prior to the adoption of the inflation-targeting framework. 1990-2010: *De facto* moving band around the US dollar.
Chile	1990-1999 September 1999-2010	Crawling exchange rate band and announcement of inflation targets (1990-1998: *De facto* crawling band that is narrower than or equal to +/-5%; 12/1998-09/1999: Pre-announced crawling band that is wider than or equal to +/-2%). Inflation-targeting. 1985-1995: policy rate - real rate on indexed Central Bank of Chile paper of 90 days maturity. From May 1995, real overnight interbank loan rate. *De jure* independent float (foreign exchange market intervention in exceptional instances; operations are transparent). *De facto* crawling band that is narrower than or equal to +/-5%.

Country	Monetary Policy and Exchange Rate Framework	
China, P.R. of	1994-2010 1990-1993 September 1994 1996 1998-2010	Targets on currency in circulation and banks' loans portfolios. Three monetary indicators, M0, M1 and M2. Money supply as formal intermediate target. Monetary policy framework organised around inflation as the final target, M2 as the intermediate target and base money as the operational target. The central bank also manages short- term interbank rates. 1994-07/2005: *De facto* peg; 08/2005-09/2009: Moving band, narrower than or equal to +/-2%; 10/2009-2010: *De facto* peg.
Colombia	1990-1999 September 1999-2010	Crawling exchange rate bands; use of intermediate monetary targets. Inflation-targeting. First implemented with reference paths for M3 and base money. Within the full-fledged inflation-targeting framework, the overnight repo interest rate became the policy instrument. 1990-2009: *De facto* crawling band that is narrower than or equal to +/-5%; 2010: Managed floating.
Czech Republic	1990-1997 1997 January 1997-2010	*De jure* fixed exchange rate regime, with monetary targets. Inflation-targeting, with a managed float. Key monetary policy rate – 2-week repo. 1990-1995: *De facto* crawling band that is narrower than or equal to +/-2%; 1996: *De facto* crawling band that is narrower than or equal to +/-5%; 1997-2001: *De facto* peg; 2002-2010: *De facto* crawling band that is narrower than or equal to +/-5%.
Denmark	1990-2010	1990-1999: *De facto* moving peg to the Deutsch Mark; 1999-2010: *De facto* peg to the Euro. Monetary policy instruments consist of the discount rate, the current-account rate and Danmarks Nationalbank's lending rate.
Egypt	1990s End 2000-2002 January 2003-2010	Pegged to the US dollar. Series of step devaluations. Initially intermediate targets of net domestic credit and then M2 with banks' excess reserve balances as the operational target. From June 2005, the operational target was switched to the overnight interbank interest rate. 1992-2002: *De facto* peg; 2003-2010: *De facto* crawling peg.
Hong Kong, SAR	Since 1983	Currency board.

Country	**Monetary Policy and Exchange Rate Framework**	
Hungary	1990-1995 March 1995 May 2001-2010	Fixed exchange rate against a currency basket, with a band. Adjustment at infrequent intervals. Crawling peg. Inflation-targeting adopted in May 2001. Pegged exchange rate with horizontal bands. Effective February 2008, *de jure* free floating exchange rate regime with Euro as reference currency. 1990-1993: *De facto* crawling band that is narrower than or equal to +/-5%; 1994-1998: *De facto* crawling band that is narrower than or equal to +/-2%; 1999-2001: Pre announced crawling band that is wider than or equal to +/-2%; 2002-2004: De facto crawling band that is narrower than or equal to +/-2%; 2005-2010: *De facto* crawling band that is narrower than or equal to +/-5%.
India	1990s 1999-2010	Flexible monetary-targeting approach. M3 as the nominal anchor, base money as the operating target and bank reserve balances as the operating instrument. Since 1998-1999, a broad based multiple indicator approach. Managed floating exchange rate regime without preannounced path. 1990-07/1991: *De facto* crawling peg; 08/1991-06/1995: *De facto* peg; 07/1996-07/2005: *De facto* crawling peg; 08/2005-2010: *De facto* crawling band that is narrower than or equal to +/-2%.
Indonesia	1990-July 2005 July 2005-2010	Base money as operational instrument. August 1997: IMF supported monetary programme with base money as target, with additional quantitative targets for central bank balance sheet items. In 2000, informal inflation-targeting adopted (explicit inflation targets). Base money remains as operational target. Inflation-targeting formally adopted in July 2005. The policy rate is the BI rate, and the operational target is the overnight interbank rate. 1990-07/1997: *De facto* crawling peg; 08/1997-03/1999: Freely falling; 04/1999-2005: Managed floating; 2006-2010: *De facto* crawling band that is narrower than or equal to +/-5%.
Israel	1992-2010	Inflation-targeting introduced in 1992, with full implementation in 1994. Short term interest rates on commercial bank deposits and loans with the central bank adopted as the policy instrument in 1995. 1990: *De facto* crawling band that is narrower than or equal to +/-2%; 1991-1993: *De facto* crawling band that is narrower than or equal to +/-5%; 1994-2004: Pre-announced crawling band that is narrower than or equal to +/-2%; 2005-2010: De- facto crawling band that is narrower than or equal to +/-5%.

Country	Monetary Policy and Exchange Rate Framework	
Japan	1990-2010	No explicitly stated nominal anchor. 1990-2001(March): Uncollateralised overnight call rate as the operating target. 1999: Zero interest rate policy (ZIRP) implemented. August 2000, ZIRP lifted. 2001-2006 (March): Banks' current account balances as operating target (quantitative easing). 2006: Return to ZIRP and overnight call rate as operating target. 1990-2010: Freely floating.
Korea	1990-1998 1998-2010	Monetary-targeting, with a variety of quantity variables used as intermediate targets. 1990s: M2. 1997: M2 and MCT (includes certificates of deposits (CD) and trust cash funds) due to M2 instability. Usefulness of MCT declined with a change to the reserve requirement system. Inflation-targeting. Overnight call money market rate as the operational target (target first announced in May 1999) but two-pillar system practised. After the crisis, M3 was used as a reference value, with a corresponding supply limit on base money. Over 2001-2003, no M3 targets were set but the aggregate continued to be monitored. Pure inflation-targeting was adopted in 2004. 1990-10/1994: Pre announced crawling band that is narrower than or equal to +/-2%; 11/1994-11/1997: *De facto* crawling peg; 12/1997-06/1998: Freely falling; 07/1998-2010: Managed floating.
Malaysia	1990-2010	Shift from monetary-targeting to interest rate-targeting in the mid-1990s. September 1998-April 2004, the policy rate was the 3-month Intervention Rate. From April 2004 onwards, the Overnight Policy Rate (OPR) has been the monetary policy stance indicator. It is the target for the average overnight interbank rate. Fixed exchange rate regime: September 1998-July 2005. *De jure* managed float from July 2005. 1990-07/1997: *De facto* crawling band that is narrower than or equal to +/-2%; 08/1997-09/1998: Freely floating; 09/1998-06/2005: Pre-announced peg; 07/2005-2007: *De facto* peg; 2008-2010: *De facto* crawling band that is narrower than or equal to +/-5%.

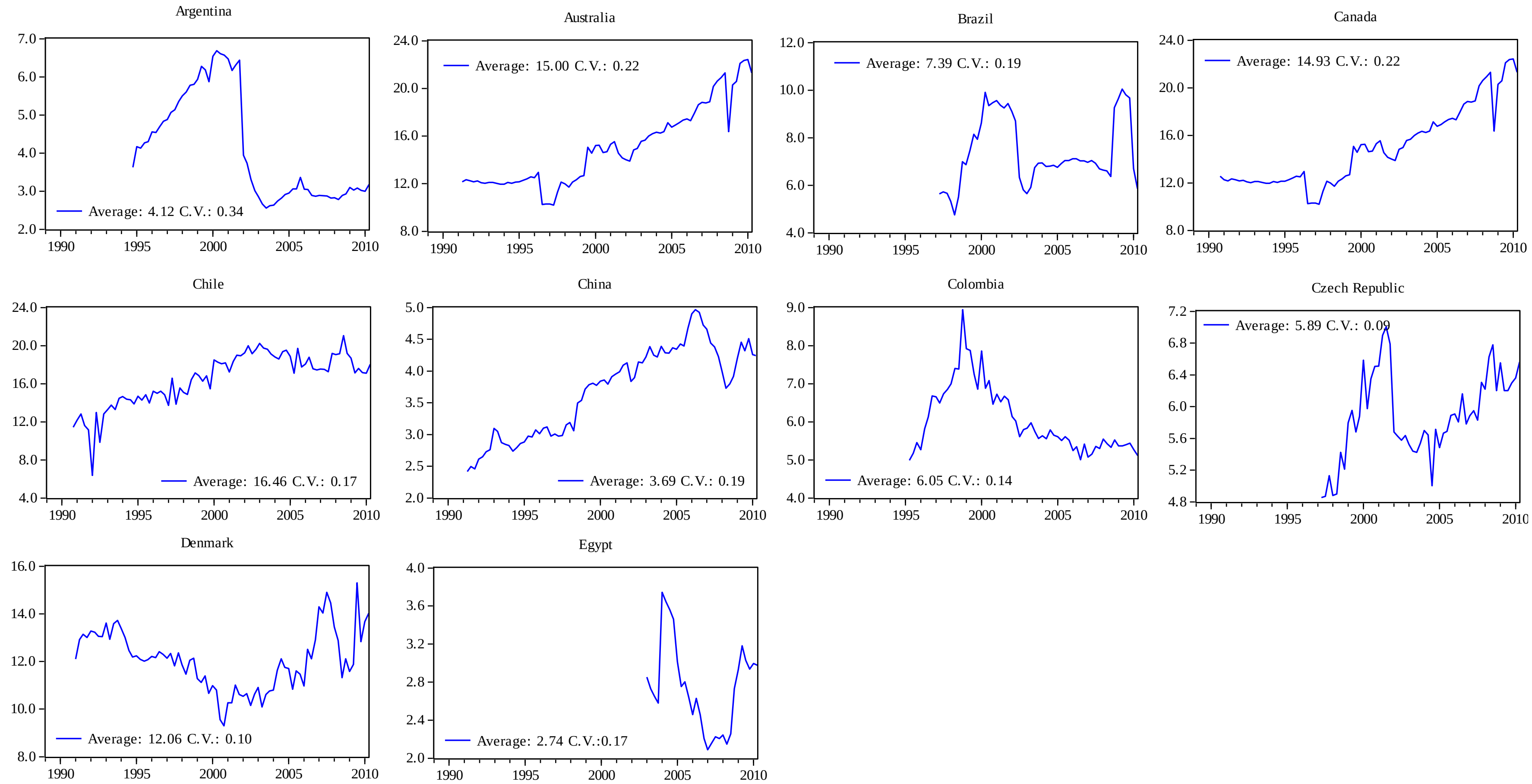
Country	Monetary Policy and Exchange Rate Framework	
Mexico	1990-1994 1999-2010	Exchange rate targeting with predetermined parity. Inflation-targeting (from January 1999). September 1995-2004: The monetary policy instrument was the commercial banks' current account balances at the central bank ("corto"). Since 2004, the central bank operated based on interest rates (the last overnight interest rate change due to "corto" was in February 2005). January 2008: The overnight interbank interest rate was formally made the operating target. 1990-1991: Pre-announced horizontal band that is narrower than or equal to +/-2%; 05/1992-01/1994: *De facto* peg; 02/1994-12/1994: Pre- announced crawling band that is wider than or equal to +/-2%; 12/1994-03/1996: Freely falling; 04/1996-2010: Managed floating.
New Zealand	1990-2010	Inflation-targeting framework adopted in 1990. Effective March 1999, the operating target and indicator of policy stance is the Official Cash Rate (the rate at which the Reserve Bank will borrow/lend). Previously, the daily settlements cash target was the main operating instrument, and the MCI was the operating target from June 1997 to March 1999. 1990-2010: Managed floating.
Norway	1990-2001 2001-2010	Exchange rate targeting. Fixed exchange rate abandoned in December 1992. Inflation-targeting framework adopted in March 2001. The monetary policy instrument is the key policy rate which is the interest rate on banks' deposits up to a quota in Norges Bank. 1990-1992: Moving band around the Deutsch Mark; 1992-2010: Managed floating/ *De facto* band around the Euro.
Peru	1991-2001 2002-2010	Targets for base money and monetary aggregates. In 2001, the central banks had as its operating target, the average of banks' reserve balances and also begin announcing benchmark interest rates on central bank operations (overnight lending and borrowing rates). Inflation-targeting. Interbank overnight interest rate as operating target. 1990-1993: Freely falling; 1994-2009: *De facto* crawling band that is narrower than or equal to +/-2%; 2010: *De facto* crawling peg.
Philippines	1990s 2002-2010	Base money-targeting. In the second half of 1995, looser observance of base money targets with adoption of inflation targets. Inflation-targeting implemented in 2002. Main policy instruments are the overnight repurchase rate (RP) and reverse repurchase rate (RRP). 1990-1991: *De facto* crawling peg; 1992: *De facto* crawling band narrower than or equal to +/-2%; 1993-08/1995: *De facto* crawling band narrower than or equal to +/-5%; 09/1995-06/1997: *De facto* peg; 07/1997-12/1997: Freely falling/floating; 12/1997-11/1999: Managed floating; 12/1999-2007: *De facto* crawling band narrower than or equal to +/-2%; 2008-2010: *De facto* crawling band narrower than or equal to +/-5%.

Country	Monetary Policy and Exchange Rate Framework	
Poland	1990-1997 1999-2010	Monetary-targeting (with elements of exchange rate targeting) Period involved M2 as intermediate target (1990-1997), shifts between short term interest rates and base money as the operational target. From February 1998 onwards, short term interest rates adopted as operational target. Inflation targets present since 1992. Inflation-targeting. 1990-04/1993: Freely falling exchange rate; 05/1993-05/1995: Dual market; 05/1995-04/2000: *De facto* crawling band (preannounced bands); 04/2000-2010: Managed floating.
Russia	1992-2010	Russian Ruble introduced in July 1993. Monetary policy generally focussed on disinflation and more recently on resisting the nominal exchange rate appreciation. Key monetary policy instruments are the refinancing rate and reserve requirement ratios. 1992-07/1996: Freely falling/dual market exchange rate; 08/1996-08/1998: Dual market; 08/1998-11/1999; Freely falling/dual market; 12/1999-2010: *De facto* crawling band.
Singapore	Since 1981	Managed floating against a basket of currencies of major trading partners and competitions. Basket, band, crawl framework. Intermediate target: NEER.
South Africa	1990-1998 2000-2010	Monetary-targeting (M3 was used as the intermediate target). In the late 1990s, as financial liberalisation complicated monetary-targeting, an eclectic approach was adopted with a focus on numerous indicators. Inflation-targeting framework formally adopted in February 2000. The policy rate is the 7-day repo rate. 1990-03/1995: Dual rate/Managed floating; 03/1995-2010: Freely floating.
Taiwan	1990-2010	Monetary-targeting. Since 1992, M2 has been the intermediate target. Target zones for M2 growth are publicly announced. Base money is the operational target. A variety of operational instruments are used including open market operations, required reserve ratios and re-deposits of financial institutions. Managed floating exchange rate regime.

Country	**Monetary Policy and Exchange Rate Framework**	
Thailand	1990- July 1997	*De facto* peg
	July 1997- May 2000	IMF supported monetary-targeting programme. Daily and quarterly base money targets. July 1997- January 1998: Freely falling/free floating exchange rate regime. 1998 -1999: Managed floating. 2000-2010: Moving band that is narrower than or equal to +/-2%.
	May 2000 – 2010	Inflation-targeting. 2-week repo rate adopted as policy interest rate up to January 2007, which was then switched to the 1-day repo rate. Effective February 2008, the 1 day bilateral repo rate is the policy interest rate.
Turkey	1990s	Various forms of a monetary-targeting approach with announcements of a predetermined exchange rate path.
	2000	IMF supported exchange rate stabilisation programme.
	2001-2006	Monetary-targeting and implicit inflation-targeting. Base money as nominal anchor (2001-2002) and adjustment of short term interest rates.
	2006	Full-fledged inflation-targeting (January 2006). 1990-01/1998: Freely falling/managed floating; 02/1998-01/2001: *De facto* crawling band that is narrower than or equal to +/-5%; 02/2001-03/2002: Freely falling; 04/2003-07/2007: Freely floating; 08/2007-2010: *De facto* crawling band that is narrower than or equal to +/-5%.

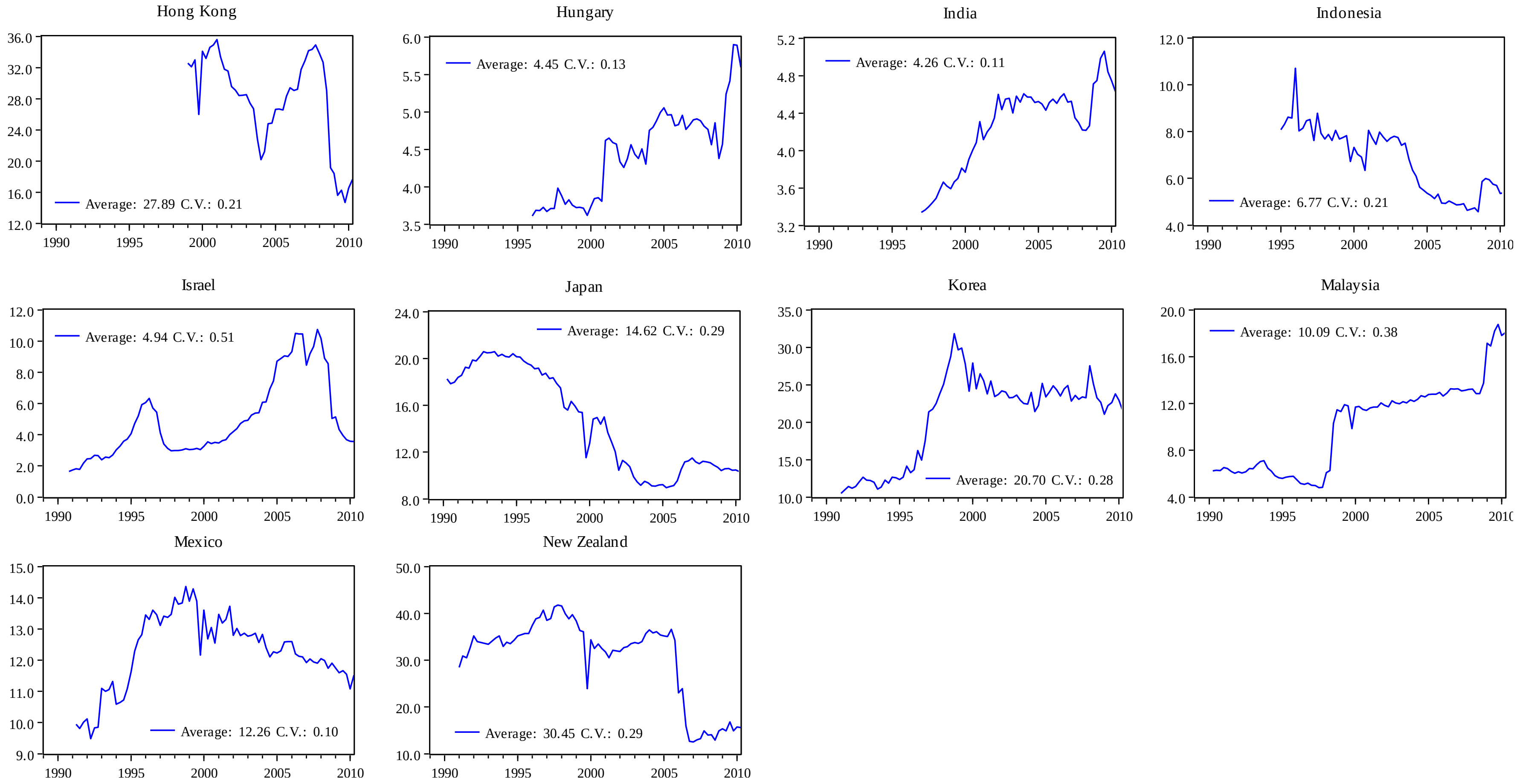
Notes:
Information on *De facto* exchange rate regimes is taken from Ilzetzki *et al.* (2011). All other text on monetary policy frameworks and *de jure* exchange rate regimes are based on various sources including central bank websites, various publications, and the IMF Classification of Exchange Rate Arrangements and Monetary Frameworks (http://www.imf.org/external/NP/mfd/er/index.aspx).

APPENDIX 4: BROAD MONEY MULTIPLIERS[107]

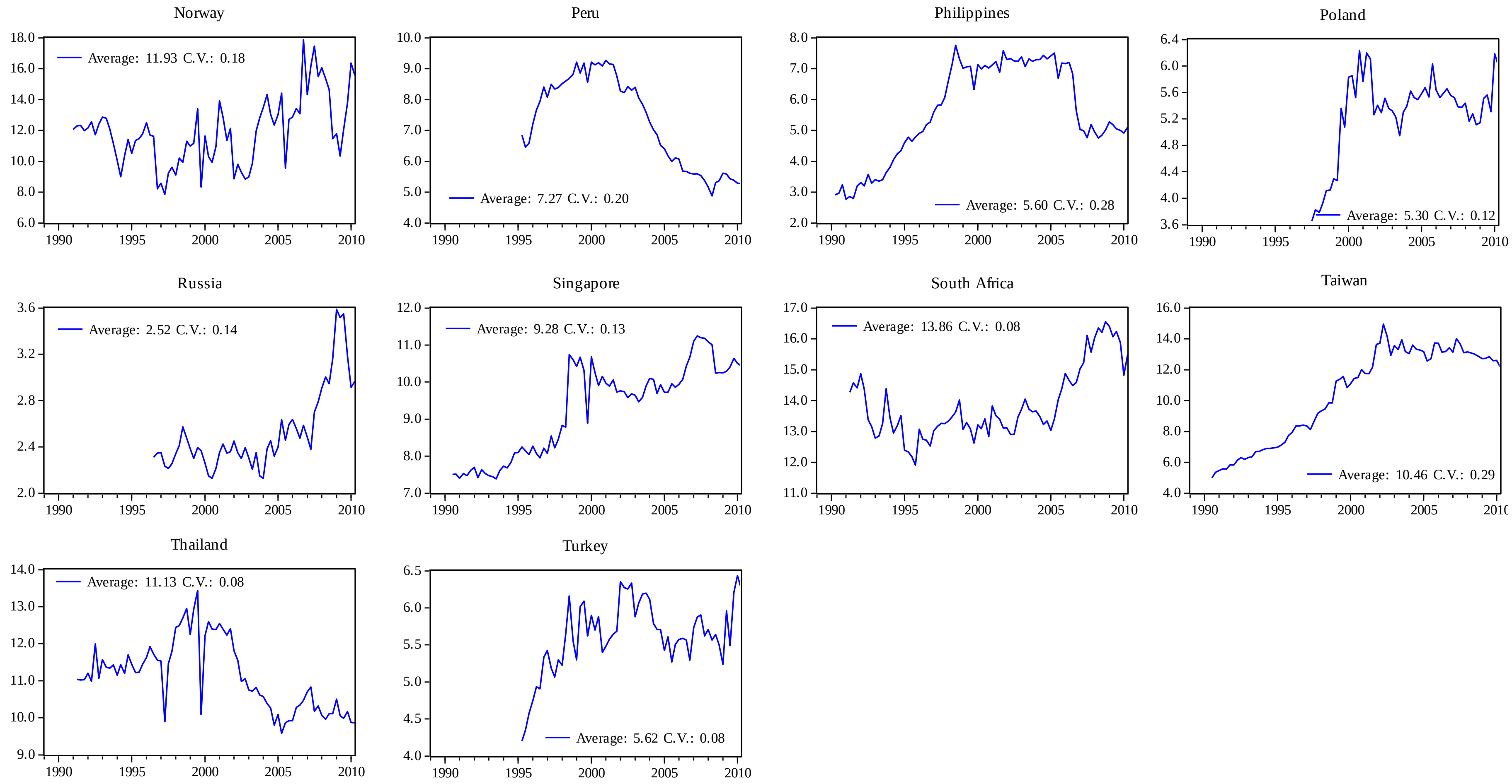


[107] The broad money multiplier is the ratio between seasonally adjusted broad money and seasonally adjusted base money. For each country, the average value and coefficient of variation (C.V.) are reported.

APPENDIX 4: BROAD MONEY MULTIPLIERS (CONTINUED)



APPENDIX 4: BROAD MONEY MULTIPLIERS (CONTINUED)



Appendix 5
Structural Break Tests for Real Intervention Effects on Real Base Money Change due to Monetary Policy Framework Changes in Selected Countries

Country	Breakpoint	Chow Test F-Statistic (probability)[#]	Notes
Asia			
China	1998q1	0.465 (0.855)	Reduction in reserve requirement ratio.
	2006q4	0.890 (0.521)	Subsequent large increases in reserve requirement ratios.
India	2006q4	1.649 (0.161)	Subsequent increases in reserve requirement ratio.
Indonesia	2005q2	0.580 (0.768)	Inflation-targeting implemented in July 2005. Overnight interbank rate as operational target.
Korea	1997q1	0.293 (0.938)	Reduction in reserve requirement ratio.
	1999q2	1.117 (0.364)	Implementation of inflation-targeting (1998) and adoption of call money market rate targets (from May 1999).
Malaysia	1998q2	1.982* (0.082)	Sharp reduction in reserve requirement ratio.
	1998q3	1.414 (0.224)	Fixed exchange rate regime beginning September 1998.
	2005q3	0.295 (0.937)	Managed floating regime from July 2005.
Philippines	1995q2	0.222 (0.802)	Looser observance of base money targets in the second half of 1995.
	2002q1	1.275 (0.286)	Implementation of inflation-targeting (January 2002).
	2006q2	0.362 (0.698)	Implementation of reserve deposit account (RDA) in March 2006.
Thailand	2000q2	0.137 (0.995)	Inflation-targeting implemented in May 2000.
Latin America			
Argentina	2002q1	0.898 (0.528)	Collapse of currency board in January 2002.
Brazil	1999q1	2.263* (0.097)	Inflation-targeting implemented in January 1999.
Chile	1999q3	0.095 (0.984)	Inflation-targeting implemented in September 1999.
Colombia	1999q3	2.281** (0.040)	Inflation-targeting implemented in September 1999.
Mexico	1999q1	3.514*** (0.004)	Inflation-targeting implemented in January 1999.
	2005q2	2.243** (0.045)	Last use of account balances with central bank as operating target in February 2005.
Peru	2002q1	2.574** (0.028)	Inflation-targeting implemented in 2002.

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 5: Continued

Country	Breakpoint	Chow Test F-Statistic (probability)[#]	Notes
Other Emerging Market Economies			
Hungary	2001q2	1.018 (0.437)	Inflation-targeting implemented in May 2001.
Israel	1995q1 1996q2	1.122 (0.363) 1.821* (0.090)	Short-term interest rates adopted as policy instrument in 1995. Large interventions over February 1996-June 1997 sterilised through interest-bearing deposits at the central bank.
South Africa	2000q1	0.789 (0.582)	Inflation-targeting adopted in February 2000.
Turkey	2006q1	2.503* (0.056)	Inflation-targeting formally adopted in January 2006. Short-term interest rates main policy tool since 2002.
Developed Economies			
Japan	1999q1 2001q1 2006q1	2.089* (0.058) 2.542** (0.023) 2.205** (0.046)	Zero interest rate policy (ZIRP) implemented. Banks' current account balances as operation target from March 2001 until March 2006. Return to ZIRP.
New Zealand	2006q3	3.511*** (0.004)	New liquidity framework introduced in July 2006.
Norway	2001q1	0.374 (0.864)	Inflation-targeting adopted in March 2001.

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

<u>Appendix 6</u>:
Structural Break Tests for All Parameters in Baseline Real Base Money Growth Change Regressions

Country	Quandt-Andrews/ Andrews-Ploberger Tests			Chow Test	
	Unknown Breakpoint [Trimming]	**Sup-W Statistic (p-value)**	**Exp-W Statistic (p-value)**	**Regression Sample Midpoint**	**F-statistic (p-value)**
Asia					
China	2005q3 [25%]	27.081 (0.528)	9.948 (0.651)	2001q1	0.625 (0.863)
Hong Kong	2004q2 [35%]	24.836 (0.317)	10.834 (0.239)	2005q1	1.204 (0.373)
India	2005q3 [25%]	55.074*** (0.000)	24.115*** (0.000)	2004q1	3.528*** (0.003)
Indonesia	2003q4 [25%]	18.529 (0.705)	7.326 (0627)	2003q1	0.668 (0.787)
Korea	1998q1 [20%]	28.924* (0.061)	11.217* (0.063)	2001q1	1.070 (0.403)
Malaysia	1998q1 [20%]	39.981*** (0.001)	16.781*** (0.007)	2000q3	0.992 (0.478)
Philippines	1997q3 [35%]	11.715 (0.295)	3.925 (0.324)	2000q4	0.675 (0.671)
Singapore	2000q2 [40%]	18.574 (0.565)	7.206 (0.611)	2000q4	1.023 (0.449)
Thailand	2000q3 [30%]	35.792 (0.168)	14.528 (0.203)	2001q1	1.097 (0.394)
Latin America					
Argentina	2001q1 [30%]	38.431** (0.036)	17.181** (0.021)	2002q4	1.754* (0.091)
Brazil	2000q4 [25%]	12.395 (0.938)	4.795 (0.870)	2004q1	0.593 (0.830)
Chile	2006q3 [15%]	20.271 (0.293)	7.500 (0.253)	2000q4	0.463 (0.907)
Colombia	2000q2 [20%]	34.050** (0.013)	13.609** (0.014)	2003q1	1.014 (0.456)
Mexico	2000q4 [49%]	51.436*** (0.000)	25.618*** (0.000)	2001q1	3.401*** (0.000)
Peru	2003q3 [45%]	94.223*** (0.000)	45.320*** (0.000)	2003q1	1.180 (0.119)

Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 6: Continued

Country	Quandt-Andrews/ Andrews-Ploberger Tests			Chow Test	
	Unknown Breakpoint	QLR Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Other Emerging Market Economies					
Czech Republic	2001q2 [30%]	13.155 (0.586)	5.152 (0.471)	2004q1	0.761 (0.652)
Hungary	2004q1 [40%]	14.917 (0.868)	6.533 (0.786)	2003q3	0.637 (0.824)
Israel	2004q1 [20%]	17.184 (0.780)	6.426 (0.729)	2000q4	0.522 (0.901)
Poland	2007q2 [25%]	10.224 (0.970)	3.435 (0.965)	2004q2	0.518 (0.875)
Russia	2005q1 [30%]	25.455 (0.268)	10.928 (0.184)	2003q4	1.323 (0.257)
South Africa	1995q2 [20%]	37.380** (0.013)	15.083** (0.014)	2001q1	1.058 (0.417)
Turkey	2001q1 [35%]	16.043 (0.383)	6.627 (0.293)	2003q1	0.911 (0.533)
Developed Economies					
Australia	1996q3 [25%]	23.993 (0.491)	10.061 (0.382)	2001q1	1.215 (0.297)
Canada	2004q2 [30%]	20.113 (0.435)	8.561 (0.309)	2000q4	1.134 (0.353)
Denmark	2004q2 [15%]	23.093 (0.096)	8.843 (0.072)	2001q1	1.272 (0.271)
Japan	2001q2 [45%]	30.563*** (0.002)	13.435*** (0.002)	2000q3	2.693** (0.011)
New Zealand	2004q3 [30%]	39.194*** (0.003)	16.850*** (0.002)	2001q1	1.919* (0.052)
Norway	2000q4 [49%]	7.719 (0.878)	3.860 (0.819)	2001q1	0.714 (0.730)

Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 7:
Structural Break Tests for Real Intervention Effects on Real Broad Money Change due to Monetary Policy Framework Changes in Selected Countries

Country	Breakpoint	Chow Test F-Statistic (probability)[#]	Notes
Asia			
China	1998q1	1.430 (0.204)	Reduction in reserve requirement ratio.
	2006q4	1.474 (0.186)	Subsequent large increases in reserve requirement ratios.
India	2006q4	1.485 (0.208)	Subsequent increases in reserve requirement ratio.
Indonesia	2005q2	0.659 (0.705)	Inflation-targeting implemented in July 2005. Overnight interbank rate as operational target.
Korea	1997q1	0.682 (0.665)	Reduction in reserve requirement ratio.
	1999q2	2.386** (0.039)	Implementation of inflation-targeting (1998) and adoption of call money market rate targets (from May 1999).
Malaysia	1998q2	2.670** (0.030)	Reduction in reserve requirement ratio.
	1998q3	2.877** (0.021)	Fixed exchange rate regime beginning September 1998.
	2005q3	1.041 (0.402)	Managed floating regime from July 2005.
Philippines	1995q2	2.487** (0.032)	Looser observance of base money targets in the second half of 1995.
	2002q1	0.961 (0.460)	Implementation of inflation-targeting.
	2006q2	0.786 (0.584)	Implementation of reserve deposit account (RDA) in March 2006.
Thailand	2000q2	0.262 (0.901)	Inflation-targeting implemented in May 2000.
Latin America			
Chile	1999q3	0.616 (0.543)	Inflation-targeting implemented in September 1999.
Colombia	1999q3	0.379 (0.861)	Inflation-targeting implemented in September 1999.
Mexico	1999q1	2.079* (0.072)	Inflation-targeting implemented in January 1999.
	2005q2	0.443 (0.847)	Last use of account balances with central bank as operating target in February 2005.
Peru	2002q1	0.369 (0.894)	Inflation-targeting implemented in 2002.

[#] The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 7: Continued

Country	Breakpoint	Chow Test F-statistic (probability)#	Notes
Other Emerging Market Economies			
Hungary	2001q2	1.251 (0.254)	Inflation-targeting implemented in May 2001.
Israel	1995q1	2.294** (0.031)	Short-term interest rates adopted as policy instrument in 1995.
	1996q2	0.801 (0.704)	Large interventions over February 1996-June 1997 sterilised through interest-bearing deposits at the central bank..
South Africa	2000q1	1.338 (0.172)	Inflation-targeting adopted in February 2000.
Turkey	2006q1	0.147 (0.980)	Inflation-targeting formally adopted in January 2006.
Developed Economies			
Japan	1999q1	1.464 (0.215)	Zero interest rate policy (ZIRP) implemented.
	2001q1	1.442 (0.220)	Banks' current account balances as operation target from March 2001 until March 2006.
	2006q1	1.209 (0.316)	Return to ZIRP.
New Zealand	2006q3	3.211*** (0.008)	New liquidity framework introduced in July 2006.
Norway	2001q1	0.724 (0.669)	Inflation-targeting adopted in March 2001.

The coefficients that are allowed to vary under the alternative hypothesis are the constant term and seasonal factors, the contemporaneous and lagged coefficients on real intervention, and the lagged coefficients on the change in real base money.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 8:
Structural Break Tests for All Parameters in Baseline Real Broad Money Growth Regressions

Country	Quandt-Andrews/ Andrews-Ploberger Tests			Chow Test	
	Unknown Breakpoint [Trimming]	**Sup-W Statistic (p-value)**	**Exp-W Statistic (p-value)**	**Regression Sample Midpoint**	**F-statistic (p-value)**
Asia					
China	2003q4 [30%]	33.478 (0.257)	14.006 (0.248)	2000q4	0.634 (0.863)
Hong Kong	2002q4 [35%]	37.737** (0.016)	16.276** (0.014)	2004q2	1.014 (0.485)
India	2005q3 [30%]	28.845* (0.064)	11.530* (0.070)	2004q1	1.054 (0.436)
Indonesia	2002q4 [40%]	1.579 (0.158)	1.174 (0.232)	2002q4	1.579 (0.189)
Korea	1999q2 [15%]	22.734 (0.322)	8.282 (0.327)	2000q2	1.055 (0.414)
Malaysia	1997q3 [20%]	31.945** (0.040)	13.447** (0.026)	2000q4	1.278 (0.255)
Philippines	1995q1 [15%]	32.309*** (0.009)	12.994*** (0.007)	2000q4	1.380 (0.212)
Singapore	2005q3 [15%]	14.942 (0.489)	5.388 (0.381)	2000q2	1.555 (0.156)
Thailand	1994q3 [15%]	22.986 (0.226)	8.441 (0.217)	2000q4	0.378 (0.959)
Latin America					
Argentina	2002q2 [30%]	52.854*** (0.000)	23.292*** (0.000)	2002q4	2.488** (0.014)
Brazil	2004q1 [49%]	166.864*** (0.000)	82.739*** (0.000)	2004q2	2.842** (0.035)
Chile	1997q4 [15%]	18.395 (0.431)	7.421 (0.264)	2000q4	0.507 (0.879)
Colombia	2002q4 [20%]	28.955** (0.023)	11.464** (0.020)	2003q1	2.819*** (0.009)
Mexico	2004q1 [25%]	48.654*** (0.001)	21.135*** (0.001)	2001q1	1.318 (0.231)
Peru	1999q4 [25%]	29.208 (0.103)	12.367* (0.069)	2003q1	1.175 (0.338)

Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 8: Continued

Country	Quandt-Andrews/ Andrews-Ploberger Tests			Chow Test	
	Unknown Breakpoint [Trimming]	Sup-W Statistic (p-value)	Exp-W Statistic (p-value)	Regression Sample Midpoint	F-statistic (p-value)
Other Emerging Market Economies					
Czech Republic	2003q2 [40%]	161.008*** (0.000)	78.201*** (0.000)	2004q1	1.728 (0.158)
Hungary	2005q2 [25%]	22.468 (0.253)	9.113 (0.474)	2003q3	1.164 (0.347)
Israel	1996q2 [25%]	45.956*** (0.006)	19.341*** (0.006)	2001q1	0.805 (0.683)
Poland	2003q1 [40%]	45.170*** (0.005)	20.388*** (0.004)	2004q3	1.185 (0.391)
Russia	2000q3 [25%]	29.169 (0.104)	12.678* (0.057)	2003q2	1.151 (0.360)
South Africa	1994q3 [20%]	20.763 (0.602)	8.517 (0.460)	2000q3	1.236 (0.279)
Turkey	2000q1 [30%]	46.836*** (0.000)	21.064*** (0.000)	2003q1	0.218 (0.999)
Developed Economies					
Australia	1999q1 [25%]	26.157 (0.590)	11.143 (0.476)	2000q4	0.934 (0.550)
Canada	2005q3 [25%]	23.494 (0.690)	8.712 (0.747)	2001q1	0.579 (0.894)
Denmark	1998q2 [25%]	16.511 (0.361)	6.976 (0.203)	2000q3	1.830* (0.082)
Japan	2002q3 [30%]	23.938** (0.044)	9.864** (0.030)	2001q1	1.773* (0.094)
New Zealand	2003q2 [15%]	25.446 (0.124)	9.838* (0.097)	2001q1	1.230 (0.290)
Norway	1998q1 [25%]	34.385** (0.016)	14.382** (0.013)	2000q3	1.113 (0.369)

Sup-W: Maximum of Wald statistics; Exp-W: average of exponential Wald statistics.
The Quandt-Andrews Sup-W test statistic corresponds to the maximum of the sequence of Wald test statistics for different potential breakpoints. The unknown breakpoint is the date where the maximum statistic is recorded and therefore, the most likely breakpoint location. The Andrews-Ploberger Exp-W test statistic corresponds to the average of the exponential of the same sequence of Wald test statistics.
The distribution of these test statistics is non-standard and the p-values follow Hansen (1997). A portion of the sample is excluded from the test. This trimming percentage, equally split between the beginning and the end of the sample for each country, is the lowest percentage that allows for enough observations to identify subsample parameters. The standard 15% is used as minimum trimming where possible.
***significant at the 1% level; **significant at the 5% level, *significant at the 10% level.

Appendix 9:
Equality Tests of the Aizenman-Chinn-Ito Trilemma Measures Grouped by the Boxplot Quartiles of Real Intervention Effects on Real Broad Money Change

		Upper quartile	Inter-quartile	Lower quartile	Equality Test Statistic
		Group Average [Median]			
Baseline Scenario					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		0.370***	0.137	-0.154	
	Monetary independence	0.413	0.394	0.445	0.619
	Exchange rate stability	[0.423]	[0.388]	[0.271]	3.286
	Financial openness	0.670	0.640	0.469	0.970
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		1.360***	0.373***	-0.231	
	Monetary independence	0.366	0.410	0.459	1.652
	Exchange rate stability	[0.382]	[0.417]	[0.348]	2.253
	Financial openness	0.599	0.637	0.543	0.219
Robustness Analysis (1)					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		0.422***	0.125	-0.218	
	Monetary independence	0.413	0.399	0.434	0.295
	Exchange rate stability	[0.423]	[0.352]	[0.346]	2.349
	Financial openness	0.670	0.629	0.488	0.725
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		1.353***	0.317***	-0.296	
	Monetary independence	0.367	0.407	0.467	1.760
	Exchange rate stability	[0.423]	[0.417]	[0.348]	3.553
	Financial openness	0.556	0.667	0.578	0.603
Robustness Analysis (2)					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		0.360***	0.124	-0.225	
	Monetary independence	0.377	0.432	0.405	0.723
	Exchange rate stability	[0.423]	[0.392]	[0.271]	4.178
	Financial openness	0.745	0.562	0.549	1.036
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal BM_{br}		1.484**	0.319	-0.691	
	Monetary independence	0.354	0.431	0.417	1.407
	Exchange rate stability	[0.395]	[0.390]	[0.339]	1.760
	Financial openness	0.625	0.608	0.579	0.034

Notes:
The trilemma measures are based on Aizenman *et al.* (2010). The monetary independence index measures the reciprocal of the correlation between home country and base country money market rates. A higher value indicates higher monetary independence. The exchange rate stability index captures the standard deviation in the exchange rate between the home country and the base country. A higher value indicates higher exchange rate stability. The financial openness index is the *de jure* capital account openness index developed by Chinn and Ito (2008) based on restrictions detailed in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).
We have averaged the annual values of the indices for each country in line with the regression sample period.
Robustness Analysis (1) refers to the use of regression results based on robust standard errors for selected countries.
Robustness Analysis (2) refers to the use of results from unrestricted regressions.
The mean equality test is the single-factor ANOVA F-test. The median equality test is the Kruskal-Wallis test.
The median equality test is used when non-normality is detected in the series being tested.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Appendix 10:
Equality Tests of the Aizenman-Chinn-Ito Trilemma Measures Grouped by the Boxplot Quartiles of Real Intervention Effects on Real Base Money Change

		Upper quartile	Inter-quartile	Lower quartile	Equality Test Statistic
		Group Average [Median]			
Baseline Scenario					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.283***	0.032	-0.062	
	Monetary independence	0.444	0.388	0.432	0.939
	Exchange rate stability	[0.444]	[0.366]	[0.365]	0.974
	Financial openness	0.506	0.654	0.595	0.565
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.343***	0.055***	-0.053*	
	Monetary independence	0.411	0.391	0.449	0.470
	Exchange rate stability	[0.398]	[0.390]	[0.348]	1.846
	Financial openness#	0.610	0.682	0.454	2.238
Robustness Analysis (1)					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.283***	0.047	-0.060	
	Monetary independence	0.440	0.391	0.416	0.659
	Exchange rate stability	[0.440]	[0.390]	[0.324]	2.401
	Financial openness	0.506	0.709	0.520	1.546
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.375***	0.074***	-0.066	
	Monetary independence	0.413	0.395	0.436	0.414
	Exchange rate stability	[0.346]	[0.452]	[0.342]	5.428*
	Financial openness#	0.601	0.672	0.497	1.129
Robustness Analysis (2)					
Short-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.257**	0.040	-0.044	
	Monetary independence	0.436	0.385	0.439	0.991
	Exchange rate stability	[0.444]	[0.407]	[0.299]	4.891*
	Financial openness	0.554	0.705	0.453	1.903
Long-run coefficient for the effect of ΔReal FXR_{cb} on ΔReal RM_{res}		0.344**	0.070	-0.097	
	Monetary independence	0..413	0.419	0.394	0.150
	Exchange rate stability	[0.346]	[0.407]	[0.382]	0.817
	Financial openness	0.601	0.633	0.550	0.172

Notes:
The trilemma measures are based on Aizenman *et al.* (2010). The monetary independence index measures the reciprocal of the correlation between home country and base country money market rates. A higher value indicates higher monetary independence. The exchange rate stability index captures the standard deviation in the exchange rate between the home country and the base country. A higher value indicates higher exchange rate stability. The financial openness index is the *de jure* capital account openness index developed by Chinn and Ito (2008) based on restrictions detailed in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).
We have averaged the annual values of the indices for each country in line with the regression sample period.
Robustness Analysis (1) refers to the use of regression results based on robust standard errors for selected countries.
Robustness Analysis (2) refers to the use of results from unrestricted regressions.
The mean equality test is the single-factor ANOVA F-test or the Welch F-test for unequal variances.
Welch F-test statistic. The ANOVA F-test is not statistically significant.
The median equality test is the Kruskal-Wallis test; used when non-normality is detected in the series being tested.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

APPENDIX 11: COUNTRY CHARACTERISTICS – INDIVIDUAL COUNTRY DATA

Country	Openness		Current Account Balance		Capital Account Balance		Net Direct and Portfolio Investment Balance		Net Other Investment Balance		Intervention Indicators			GDP per capita (Y/c)	Exchange Rate Flexibility (ERF)
	CAO	KAO	CAS	CAB	KAS	KAB	DIPIS	DIPIB	OIS	OIB	FXIV	RA	FXIS		
Argentina	0.385	0.113	0.529	-0.462	0.647	0.140	0.750	2.363	0.125	-1.787	0.538	0.121	0.500	10.455	5.941
Australia	0.486	0.210	0.000	-4.588	1.000	4.650	0.947	4.309	0.474	0.158	0.434	0.032	0.447	*28.425*	*13.000*
Brazil	0.280	0.076	0.357	-1.294	0.786	2.640	1.000	3.425	0.231	-0.660	0.490	0.192	0.680	8.469	*11.286*
Canada	0.807	0.166	0.550	0.041	0.550	0.135	0.368	-0.078	0.368	-0.291	0.089	0.032	0.579	*29.387*	*8.900*
Chile	0.798	0.240	0.333	-0.064	0.714	1.315	1.000	0.656	0.429	1.452	0.656	0.233	0.596	9.855	*9.857*
China	0.586	0.090	0.950	5.649	0.750	2.067	0.947	2.731	0.316	-0.207	0.986	1.398	0.948	3.165	6.050
Colombia	0.392	0.083	0.125	-2.218	0.938	3.302	0.933	2.680	0.467	-0.044	0.276	0.113	0.583	6.994	*10.125*
Czech	1.531	0.169	0.000	-2.985	1.000	4.622	0.750	4.341	0.800	-0.031	0.650	0.250	0.570	*18.978*	*7.857*
Denmark	1.088	0.340	0.952	2.235	0.429	-0.737	0.450	-1.824	0.700	1.104	0.946	0.297	0.538	*28.646*	5.286
Hong Kong	4.173	1.408	1.000	8.836	0.250	-2.024	0.250	-9.531	0.500	2.524	3.074	1.071	0.694	*34.653*	2.000
Hungary	1.634	0.547	0.133	-6.410	1.000	7.892	0.857	4.378	0.643	2.544	1.320	0.359	0.571	*14.733*	*9.000*
India	0.451	0.061	0.286	-0.899	1.000	3.562	1.000	1.853	0.923	1.544	0.667	0.329	0.647	2.103	7.357
Indonesia	0.642	0.065	0.813	3.436	0.375	-0.313	0.733	1.261	0.200	-1.394	0.425	0.178	0.633	3.008	*10.563*
Israel	0.893	0.163	0.400	-0.060	0.700	1.400	0.421	0.207	0.526	0.266	0.701	0.444	0.605	*21.183*	*7.800*
Japan	0.282	0.121	1.000	2.901	0.190	-1.887	0.211	-1.643	0.474	-0.134	0.222	0.211	0.842	*26.194*	13.000
Korea	0.794	0.117	0.667	1.153	0.714	0.856	0.750	0.752	0.600	0.624	0.541	0.414	0.788	*18.052*	*9.952*
Malaysia	2.065	0.201	0.619	8.612	0.476	-4.475	0.714	0.430	0.238	-3.164	1.867	0.790	0.641	9.454	6.143
Mexico	0.587	0.064	0.000	-1.988	0.950	2.647	0.947	3.418	0.368	-0.428	0.331	0.134	0.684	10.883	*10.800*

(Continued on next page)

APPENDIX 11: CONTINUED

Country	Openness		Current Account Balance		Capital Account Balance		Net Direct and Portfolio Investment Balance		Net Other Investment Balance		Intervention Indicators			GDP per capita (Y/c)	Exchange Rate Flexibility (ERF)
	CAO	KAO	CAS	CAB	KAS	KAB	DIPIS	DIPIB	OIS	OIB	FXIV	RA	FXIS		
New Zealand	0.711	0.168	0.000	-5.654	0.950	6.344	0.895	3.749	0.526	2.086	0.774	0.131	0.592	*20.568*	*12.000*
Norway	0.885	0.416	1.000	11.286	0.143	-10.746	0.150	-9.855	0.650	1.643	1.317	0.144	0.538	*39.006*	*12.000*
Peru	0.502	0.088	0.313	-1.831	1.000	4.085	1.000	3.927	0.600	0.805	0.793	0.326	0.600	6.176	*7.938*
Poland	0.839	0.136	0.000	-4.674	1.000	6.010	1.000	4.072	0.750	2.489	0.712	0.203	0.673	*13.441*	*11.692*
Philippines	1.072	0.114	0.450	0.279	0.650	1.764	0.895	2.456	0.526	0.435	0.563	0.414	0.636	2.664	*8.550*
Russia	0.638	0.189	0.933	7.112	0.133	-3.276	0.571	0.172	0.357	-1.402	1.626	0.599	0.679	10.516	9.867
South Africa	0.605	0.113	0.333	-2.397	0.667	3.380	0.800	2.476	0.350	0.340	0.211	0.183	0.613	7.382	*13.476*
Singapore	4.214	0.739	1.000	17.665	0.143	-2.502	0.350	-3.995	0.100	-19.879	1.855	1.638	0.825	*34.043*	11.000
Thailand	1.269	0.147	0.600	0.838	0.700	2.496	0.947	3.033	0.421	-1.113	0.955	0.751	0.763	5.823	*8.650*
Turkey	0.558	0.094	0.125	-3.256	0.875	4.208	0.867	1.814	0.933	2.260	0.416	0.165	0.574	9.505	*12.188*

Current account/Capital account openness (CAO/KAO): average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.

Current account/Capital account surplus years (CAS/KAS): number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. A country is recorded as a surplus country in the respective account if CAS/KAS > 0.5. Net direct and portfolio investment/Other investment balance surplus years (DIPIS/OIS) are calculated in a similar manner.

Current account/Capital account balance (CAB/KAB): average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100. Net direct and portfolio investment/Other investment balance (DIPIB/OIB) are calculated in a similar manner.

Intervention volatility (FXIV) is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP. Reserve accumulation (RA) is the sum of change in foreign exchange reserves, scaled by the average annual nominal GDP. The total surplus quarters (FXIS) refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters. All data are calculated based on the regression sample period specific to each country. The data presented correspond to the real broad money growth regressions, which may differ slightly from the data that correspond to the real base money growth regressions.

All balance of payments data are sourced from the IMF Balance of Payments (BOPS) Statistics (analytic presentation, annual data, USD) with various editions downloaded via ESDS International, University of Manchester. GDP data, in USD is sourced from the World Economic Outlook (WEO) Database.

GDP per capita (Y/c) based on purchasing power parity (millions of current international dollar), taken as an annual average over the regression sample period. Source: WEO. Countries are classified into high or middle income countries based on the World Bank income group classifications (http://data.worldbank.org/about/country-classifications) *Italics: High income countries.*

Exchange rate flexibility is identified based on the historical *de facto* fine classification provided by Ilzetzki *et al.* (2011). Each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility (http://personal.lse.ac.uk/ilzetzki/IRRBack.htm). *Italics: Inflation-targeting countries.*